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INTELLECTUAL CHANGES DURING PROLONGED PERCEPTUAL ISOLATION (DARKNESS AND SILENCE)[1]

JOHN P. ZUBEK, WILMA SANSOM, AND A. PRYSIAZNIUK
University of Manitoba

SINCE THE PIONEERING WORK of Hebb and his students on the effects of perceptual isolation on human subjects, a number of experiments have been reported under the name of "sensory deprivation" studies. In general they have employed short periods of isolation, for example, 5 to 30 minutes (Rosenbaum, Dobie, & Cohen, 1959), 8 hours (Freedman, 1960; Goldberger & Holt, 1958; Held & White, 1959), 24 hours (Vernon, McGill, Gulick, & Candland, 1959), 36 hours (Wexler, Mendelson, Leiderman, & Solomon, 1958), 48 hours (Vernon & Hoffman, 1956), and 3 days (Vernon, McGill, & Schiffman, 1958). Furthermore, with the exception of two studies on rote learning (Vernon & Hoffman, 1956; Vernon & McGill, 1957) the concern seems to be almost entirely with changes in perceptual and motor processes. Appraisal of intellectual functioning has been largely ignored.

The purpose of the present experiment is two-fold: (a) the use of isolation periods of a week or longer and (b) the measurement of intellectual functioning at various intervals during isolation under conditions of constant darkness and silence.

METHOD

Isolation Chamber

A cross-sectional view of the isolation chamber is shown in Figure 1. It consists of a translucent plexiglas dome measuring 7 ft. in height, 9 ft. in diameter, and 7½ ft. at the base. It is surrounded on five sides by a system of fluorescent and incandescent lights by means of which the interior of the dome can be flooded with diffuse light of any intensity or wave-length. This complex lighting system was not utilized in the present experiment on darkness and silence. In order to soundproof the chamber, the inside and outside surface of the plexiglas dome, as well as the floor, were lined with an 8 in. layer of sound-absorbing material. Toilet facilities, a food chamber, a two-way intercom system and an air-conditioning unit are all built into the floor of the dome making it unnecessary for the subject to leave the chamber for any purpose during the isolation period. The only piece of furniture in the dome is a plastic inflated mattress on which the subject lies. Entrance to the dome is through a trapdoor in the floor which also serves as a food chamber. The plexiglas dome and its external lighting system are housed inside a semi-soundproofed chamber

[1]This research was supported by the Defence Research Board of Canada, Project no. 9425–08. The authors wish to express their appreciation to the R.C.A.F. Station, Winnipeg, for permission to use certain air force personnel as subjects.

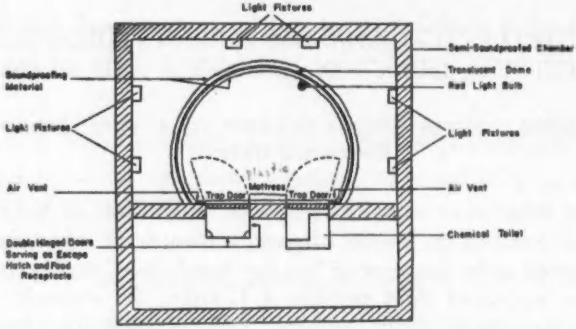

FIGURE 1. A cross-sectional view of the isolation chamber.

measuring 14 ft. × 14 ft. × 14 ft. The inside of the dome is soundproofed to the extent of 70 db. attenuation.

Tests

A battery of tests, measuring eleven different abilities, was prepared. Nine of these abilities were of an intellectual nature and two of a perceptual-motor variety. Eight equivalent forms of each test were constructed. These tests, together with their time limits are listed below.

(1) *Number Facility* (4 min.) was measured by a test consisting of relatively simple problems in arithmetic involving addition, subtraction, division, and multiplication.

(2) *Numerical Reasoning* (4 min.) was measured by a test involving the solution of various numerical sequences.

(3) *Verbal Fluency* (3 min.) S was asked to write down all the words he could think of beginning with a certain letter.

(4) *Verbal Reasoning* (3 min.) was appraised by problems such as the following: lend is to borrow as rich is to ——.

(5) *Abstract Reasoning* (4 min.) was tested by items of the type found in the abstract reasoning test of the Differential Aptitude Battery. Each problem consists of four designs or figures which make a series and S has to indicate which of the answer figures would be the next or the fifth in a series.

(6) *Space Relations* (8 min.) was measured by two tests. The first test, of two-dimensional space visualization, consists of examining a certain design or pattern and then selecting the exact parts which will fit together to make it. The second test, of three-dimensional space, consists of patterns which can be folded into figures. For each pattern, five figures are shown and S has to decide which of these figures can be made from the pattern shown.

(7) *Rote Learning* was tested by presenting aurally a list of nine three-letter words (e.g. red, ask, tub) which S was required to learn to a criterion of two successive errorless trials. The interword interval was 1 sec. and the intertrial interval 5 sec.

(8) *Recall.* S is presented with a list of 20 nonsense syllables which he studies for 3 min., reading the list over as many times as possible in the time limit. An attempt is then made to reproduce these syllables.

(9) ***Recognition.*** After the attempt at reproduction, S is shown a list containing the previously mentioned 20 nonsense syllables mixed in with 30 others. From the whole list he then attempts to select the 20 syllables which he first learned.

(10) *Perceptual Ability* (1 min.) was tested by presenting S with two pages of randomized numbers ranging from 0 to 9 and asking him to cancel all the ones or twos or threes etc.

(11) *Dexterity* was measured by three 1-min. tests. They consist of placing one dot in each triangle (⅜ in. high), making two check marks in each square (⅜ in. × ⅜ in.) and tracing a line through a maze without touching the sides.

These tests were made short deliberately in order that the total encroachment or interruption of the isolation condition would be less than one hour per testing session (once a day).

B-1

Subjects

Crit?

The subjects were paid volunteers who largely fell in the following two categories: (*a*) graduate students in the biological sciences and (*b*) air crew personnel at the R.C.A.F. Station, Winnipeg. Ss were screened psychiatrically and also for normality of EEG's. Of the initial sample of 22 Ss, six requested release from isolation within the first three days leaving 16 effective Ss; of these, 14 were in isolation for 7 days, one for 8½ days, and one for 10 days. Of the final sample of 16 Ss, four were females. The mean age of the experimental group was 24.1 years (range 19–34). The control group of 16 Ss (selected out of initial sample of 22 Ss) had the same proportion of graduate students, air crew, and the two sexes as the experimental Ss. Furthermore, they were also matched for age and intelligence scores on the Henmon-Nelson test. Almost all of this group had initially volunteered as experimental Ss. The mean age of the control group was 23.4 years (range 19–30). biased selection?

Dif between exp & control group

Procedure

The Ss were paid to lie 24 hrs. a day on a comfortable mattress in a dark and soundproofed chamber. They constantly wore a set of specially constructed comfortable earmuffs (devised by the National Research Council, Canada) which served to reduce any sounds that they might make inside the dome. They were instructed to lie as still as possible on the mattress and not to engage in any singing or humming or any other vocal or physical activity. Each S was monitored throughout the isolation period by a communication system which revealed satisfactory adherence to the instructions against making any sounds. No gauntlet-type gloves or other types of manual restrictions were imposed. A two-way speaker system allowed communication between S and *E* when necessary. An experimenter was on duty at all times.

The Ss were asked to stay in the chamber for a week and during this time were prevented as far as possible from determining what time it was. They were fed a flavourless, enriched, liquid food called "Fabulous Lady." Coffee or tea was also available at all times in the food receptacle. Occasionally sandwiches would be provided if S developed a pronounced distaste for the "Fabulous Lady."

All test administrations were performed inside the dome. The procedure was as follows: A 15-watt red light bulb located in the ceiling of the dome was put on; S removed the test battery and clipboard which were placed inside the food receptacle by *E* through a door in the bottom of the receptacle; S sat down on the "step-down" toilet seat located below the red light bulb; *E* gave S instructions for taking the tests over the two-way speaker system; the completed test battery was replaced in the food receptacle; S was asked to report any experiences he might have had since

B-2 How treat which?

the last test session; the red light was extinguished. The test battery was administered inside the chamber at the beginning of the isolation period, at intervals of approximately 24 hrs. (actual intervals might range from 18 to 30 hrs.), and one day after emerging from isolation. The total testing time rarely exceeded 45 min. No tests were administered during the seventh day (except in 10-day S) in order that EEG records could be taken. S was not told about the time intervals but only that he might be tested periodically. All of the tests were presented visually, except the rote learning test which was given over the intercom system. The order of presentation of the 11 daily tests was randomized from day to day. The equivalent forms of the tests were also randomized for the different Ss.

The control Ss were given the same tests at the same time intervals as the experimentals. All of the tests were administered inside the chamber under red light.

Results

Test Performance

Figures 2a to 2f show the mean scores obtained by the experimental and control groups on six of the eleven abilities appraised before, during, and one day after release from isolation. It can be seen that on verbal reasoning and on rote learning the experimental subjects almost invariably did better than the controls during the whole period of isolation. However, neither the difference in over-all performance on the verbal reasoning test ($p > .50$) nor that on rote learning ($p > .30$) is statistically significant nor are any of the daily differences significant. On abstract reasoning there is also no significant difference between the two groups ($p > .90$). Furthermore, the better performance of the experimental subjects during the first two days and their poorer performance during the last three days is also not significant ($p > .40$; $p > .40$, respectively). The results on the space relations test are similar to those on abstract reasoning. There is again no significant difference in over-all performance for the two groups ($p > .40$), neither is the better performance of the experimental subjects during the first four days and their inferior performance during the last two days significant ($p > .10$; $p > .30$, respectively). On the verbal fluency test the experimental subjects did less well than the controls on all six daily tests. However, on neither the over-all performance ($p > .50$) nor on any of the daily tests were the differences statistically significant. Similarly, the over-all inferior performance of the experimental group on number facility is not significant ($p > .40$) nor are any of the daily differences significant. On none of the six abilities were there any significant differences present on the post-isolation test.

Figures 3a to 3e show the scores obtained by the experimental and control groups on the five tests measuring numerical reasoning, perceptual ability, dexterity, recall, and recognition. On numerical reasoning the experimental group did less well than the controls on all six days. However, the over-all difference was not statistically significant ($p > .10$)

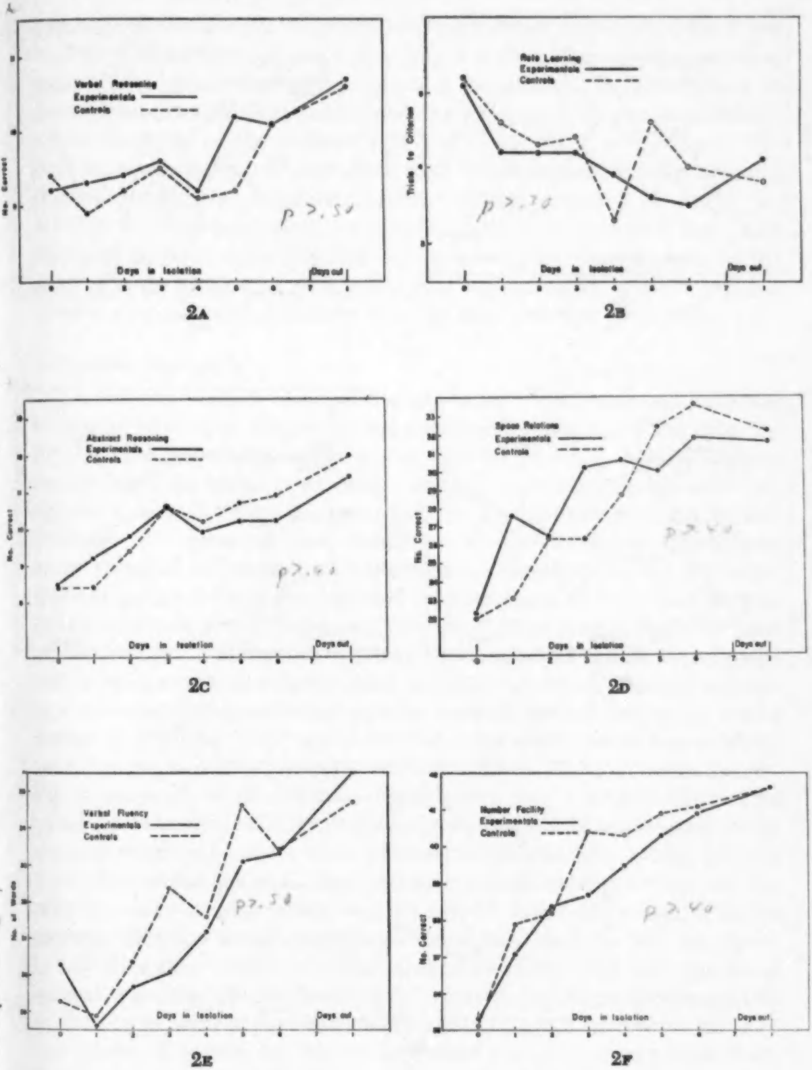

FIGURE 2. Mean scores for the experimental and control groups on six tests: rote learning, abstract reasoning, verbal reasoning, space relations, verbal fluency, and number facility. No tests were given on day 7.

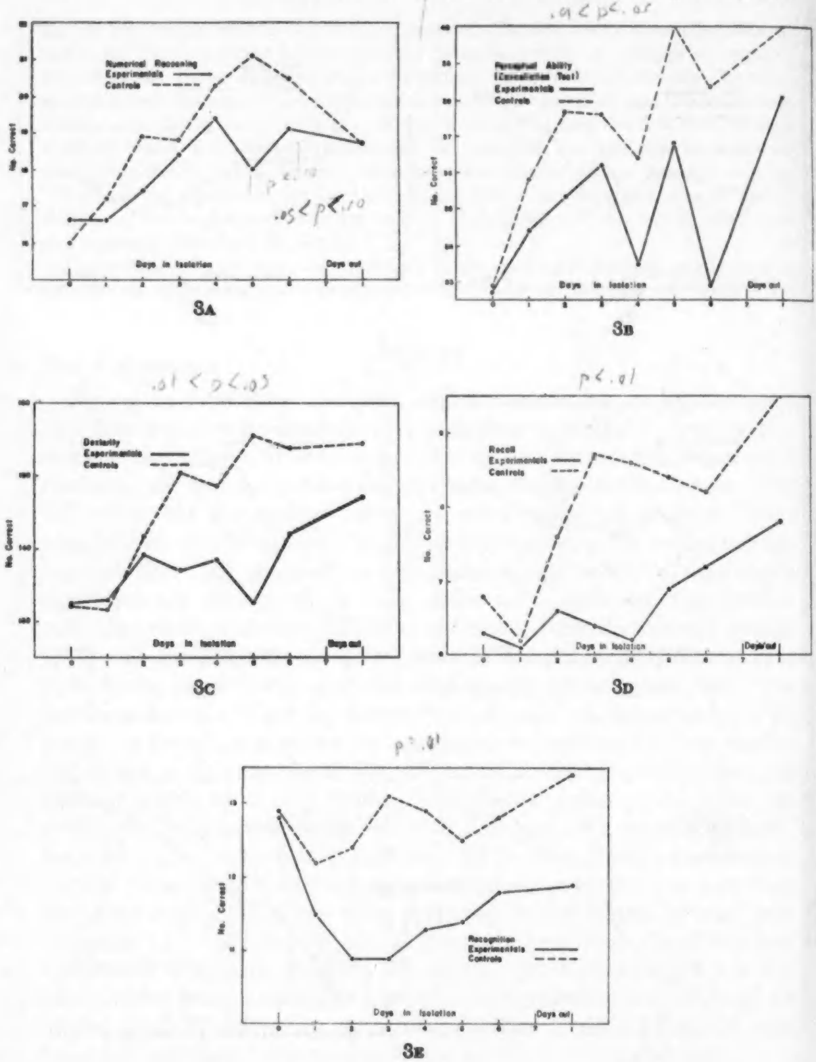

FIGURE 3. Mean scores for the experimental and control groups on five tests: numerical reasoning, perceptual ability, dexterity, recall, and recognition. No tests were given on day 7.

although on the last two days the difference almost approached the 5 per cent level of confidence ($.05 < p < .10$). On the remaining four abilities, namely perceptual, dexterity, recall, and recognition the performance of the experimental subjects (combined results, days 1–6) was significantly worse than that of the controls ($.01 < p < .05$; $.01 < p < .05$; $p < .01$; $p = .01$, respectively). On the daily tests, recall and recognition memory showed a significant impairment from the third day on ($.01 < p < .05$; $.01 < p < .05$, respectively), perceptual ability from the fourth day ($p = .05$) and dexterity from the fifth day on ($p = .01$). Furthermore, in the case of both recall and recognition the experimental subjects still exhibited a significant impairment one day after isolation ($p = .05$).

Subjective Reports

The relative absence of impairment of most of the intellectual abilities is supported to some degree by the introspective reports of the subjects. Of the 16 experimental subjects only four consistently reported (from second day) an inability to think normally with accustomed ease and efficiency, lacked ability to concentrate on a topic for very long, or had difficulty in organizing their thoughts. Of the remaining 12 subjects, seven reported no intellectual impairments whatsoever during the entire week of isolation while five reported an impairment of their thought processes only from the fifth day on. This impairment largely took the form of a reduction of motivation to think. This is typified by one subject who said it "took too much effort to think so I just vegetated." Several subjects reported that their intellectual powers were sharpened during the entire period of isolation. This can be illustrated by reference to two subjects. B3 how many?

One of these, a student taking two zoology courses, reported that a reviewing of his year's work was made much easier than normally because he could now visualize with unusual clarity various tracts and centres of the nervous system as well as other physical structures. The second subject, a member of the R.C.A.F., reported that a number of years ago he was with the navy during which time he served under more than a dozen captains and first mates. At various times since then he had attempted to visualize their faces and recall their names but with not too much success. However, during isolation he reported that he could visualize all of their faces with picture-like clarity and also recall both their first and last names. This memory feat so impressed him that upon release from the chamber he vowed that he would immediately begin the construction, in his basement, of a dome for his intellectual pursuits.

Several other experiences are worth mentioning. One of these concerns performance on the tests of recall and recognition. Several subjects reported a feeling of considerable frustration and a blankness in their minds

when they tried to recall or recognize words which they had seen several minutes before. On several occasions their performance on these tests was accompanied by vocalization of an unmentionable nature. It is interesting to note that memory lapses or absent-mindedness were mentioned by a number of subjects for a day or so after isolation. The most striking example was furnished by the 8½-day subject who on the second day after isolation went back to work. She was so disturbed by her constant forgetfulness and absent-mindedness that she ended the day in a most distraught state. A second type of experience concerns the reaction of several subjects to the dexterity test. A number of them reported that the small triangles into which they had to place a dot occasionally faded out. One subject, during the ninth and tenth days, reported that not only did the triangles fade out but also that they reappeared in another place. An examination of his test results, showing dots a half inch or so away from the triangles, seem to support his experiences. These reports would seem to suggest that the impairment of dexterity which was found to occur may have a perceptual rather than a motor origin—at least towards the end of the isolation period.

I other studies

Discussion

The foregoing results clearly indicate that prolonged perceptual isolation produces a differential effect on the various abilities tested. The purely intellectual abilities, apart from recent memory (recall and recognition), do not seem to be impaired. Furthermore, there are *suggestions* that some of these abilities, for example rote learning, verbal and abstract reasoning, and space relations may even be improved during the first few days of isolation. On the other hand, abilities of a perceptual-motor nature, as measured by the cancellation and dexterity tests, are impaired considerably. A direct comparison of these findings with those of others in the literature is difficult in view of the preoccupation by most investigators with isolation conditions of low illumination and low noise level rather than darkness and silence. However, several reports emanating from Princeton University, where work is underway under conditions very similar to those in this laboratory, confirm some of our findings. It was found, for example, that rote learning (learning lists of 12 to 15 words) was not impaired during three days of darkness and silence. Furthermore, in one of the studies (Vernon & Hoffman, 1956) a significant improvement in rote learning ability was found during the first two days while in the second study there was a suggestion of an improvement (Vernon & McGill, 1957). No impairment of the ability to concentrate or of clarity of thinking was reported (Vernon & Hoffman, 1956). Again,

Type of S would affect results greatly: used to being alone?

in line with our findings, dexterity was significantly impaired after two to three days of isolation (Vernon, McGill, Gulick, & Candland, 1959).

This absence or almost total absence of intellectual impairment under prolonged periods of darkness and silence is at variance with the results obtained under conditions of low diffuse light and low noise level. For example, Goldberger and Holt (1958) reported an inability on the part of their subjects to "think normally with ease and efficiency, a paucity of thoughts and inability to concentrate on any topic for very long"—all within a period of 8 hours. Furthermore, there was an impairment on a complex reasoning task given immediately after the eight-hour isolation period. The results of the McGill studies, where the subjects were again tested under low diffuse light and low noise level for periods up to 3 or 4 days, are also at variance with those obtained from the Manitoba and Princeton laboratories (Bexton, Heron, & Scott, 1954; Scott, Bexton, Heron, & Doane, 1959). These investigators reported that "after a few hours in isolation the subjects found that such efforts as solving problems and thinking about things tended to be abortive. They reported that the disorganization in their thinking became more pronounced as the experimental period advanced, and described their thinking in the later stages with such words as sterile, garbled, disjointed, confused, ineffectual, shallow." The results on the test batteries, which measured verbal, numerical, spatial, and learning abilities, and which were administered during and after isolation, also showed an impairment of many of the abilities. Furthermore, where the differences were not significant they were almost invariably in the direction of poorer performance for the experimental subjects. There certainly was no suggestion that the experimental group did better at any time or on any test.

The problem now arises as to the reason or reasons for these apparently conflicting results. There are several possible explanations. The first is that darkness and silence produce less general disorganization of brain function than do continuous low illumination and low noise level. Support for this view has been obtained in this laboratory where it was shown that the EEGs, although of an abnormal nature at the end of a week-long isolation period, are almost invariably back to normal within three hours after emerging from isolation. On the other hand, three McGill subjects isolated for six days under conditions of low illumination and noise level still showed abnormal EEGs, three and one-half hours after termination of isolation (Heron, Doane and Scott, 1956). This suggestion of a greater interference with normal brain function by constant low illumination and sound could, presumably, be reflected in greater intellectual impairment. Another possible explanation lies in the types of tests administered in the Manitoba and McGill laboratories. In this laboratory

all the tests, with the exception of rote learning, were presented visually while the McGill battery of tests was almost entirely of an aural nature presented over the intercom. With aural tests the factor of recent memory is of some importance and if this ability was impaired, as it was in the laboratory, it could account for the poor performance of the McGill subjects on almost all their cognitive tests. A third possible explanation lies in the shortness of our intellectual battery which was usually completed in about 45 minutes whereas the McGill battery took up to two hours. With the shorter tests, the possibility of motivational decline might be less, and consequently the performance might be better, than under a longer test session. In all likelihood, all three factors or explanations may be involved.

In conclusion it is of interest to point out some resemblances between the intellectual-perceptual changes reported in this paper and those reported in the literature on aging. It is a well established fact that recent memory, perceptual ability, and dexterity are abilities most susceptible to aging while the more complex reasoning processes are more resistant. This differential effect is essentially what characterizes the performance of our isolated subjects. The similarity is shown even more clearly in a recent study from this laboratory (Bilash & Zubek, 1960) where 634 subjects ranging in age from 16 to 89 years were given a test battery appraising eight factorially "pure" mental abilities. Many of these tests were identical with those employed in the isolation experiment. It was found that the scores on verbal fluency, numerical ability, and space relations held up extremely well with age while recent memory, dexterity, and perceptual ability showed an early and progressive loss. This similarity between the two sets of data *suggests* that prolonged sensory isolation (darkness and silence) may produce intellectual-perceptual changes similar in many respects to those found in old age.

Summary

Sixteen subjects were placed in a dark and soundproofed chamber for a period of a week or longer. A battery of tests, measuring eleven different abilities, was administered before, during, and one day after isolation. A carefully matched group of 16 control Ss were given the same tests at the same time intervals. The results indicate that there is no significant difference in performance on tests measuring verbal fluency, verbal reasoning, number facility, numercial reasoning, abstract reasoning, space relations, and rote learning. Of the intellectual abilities, only recent memory (recall and recognition) was significantly impaired. This impairment was still present one day after emerging from isolation. Two other abilities namely dexterity and perceptual ability were also significantly impaired.

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DISCRIMINATORY ABILITY OF VARIOUS SKIN AREAS AS MEASURED BY A TECHNIQUE OF INTERMITTENT STIMULATION[1]

L. A. SHEWCHUK AND JOHN P. ZUBEK
University of Manitoba

IN AN EARLIER PRELIMINARY REPORT (Shewchuk & Zubek, 1960) a description was given of a "flicker" technique for the measurement of tactual sensitivity. This technique consists of producing an interrupted stream of air at a specified pressure whose frequency can be systematically increased until the subject reports a constant sensation of pressure on some specified part of the skin. The frequency at which this constant sensation occurs is referred to as the c.f.p. or the critical frequency of percussion. The use of this method was illustrated in the measurement of the sensitivity of the finger tip. The purpose of the present experiment is to extend the use of this technique to the measurement of the discriminatory ability of ten different skin areas, namely, tongue, lip, cheek, forehead, neck, tip of index finger, thumb, hand, forearm, and upper arm.

METHOD

The apparatus that was employed was described previously (Shewchuk & Zubek, 1960). Ten university students, five males and five females, were used as Ss. They were fitted with earplugs and N.R.C. type earmuffs and seated at a table in a room adjoining the tactile machine. Ten different areas of the skin were tested. These were: tip of the tongue, middle of the red part of the lower lip, right side of cheek, middle of the forehead, back of the neck, tip of the left index finger, metacarpus of the left thumb, back of the left hand, left forearm midway between the elbow and the wrist, and the left upper arm midway between the elbow and the shoulder. Suitable stands were constructed to hold each body area in a fixed position so that only the slightest movement was possible. All skin areas were placed 0.50 cm. from the nozzle of 0.60 mm. diameter. A thin film of petrolatum was applied to each skin area under study to protect it from the drying action of the air bursts. In making measurements a constant routine was followed: each S was given a practice series consisting of one trial on each of three stimulus pressures (in reality, tank pressures) –20, 40 and 60 lbs./sq. in.–on any three of the ten skin areas. These three areas were selected at random for each S. Each trial consisted of increasing the frequency of the air bursts until S reported a constant or fused sensation. Following this practice session a skin area was randomly selected and S was given one trial, separated by a 10-sec. rest interval, on each of nine pressures of medium intensity, (20, 25, 30 . . . 60 lbs./sq. in.). After a six-min. rest interval this procedure was repeated on the next

[1]This research was supported by a grant-in-aid from the Associate Committee on Applied Psychology of the National Research Council, Canada (Grant APBT–40).

skin area and so on until all ten skin areas had been tested. This entire procedure was then repeated on four consecutive days resulting in a total of five trials on each pressure for each of the ten skin areas—for each S. Each day the various skin areas were tested in a randomized order.

Results

The main findings of the experiment are summarized in Figure 1 where the c.f.p. for each of the ten skin areas is plotted against pressure. It can be seen that most, if not all, of the ten curves show two linear parts or two limbs. In some skin areas, such as the tongue, cheek, and forehead the two limbs are more pronounced than in others such as the upper arm and lip. Figure 1 also shows that the ten curves are grouped into two distinct clusters. The top cluster, representing high discriminatory ability

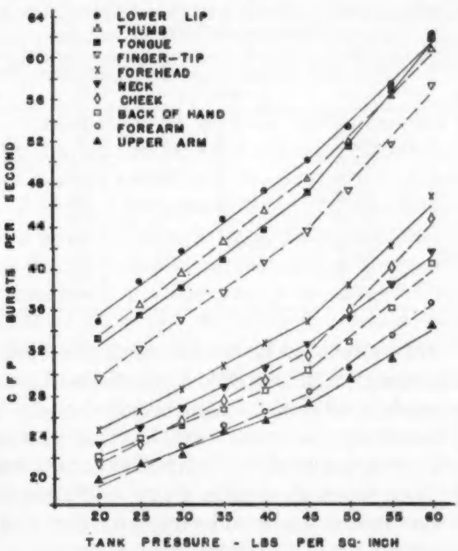

Figure 1. Relationship between c.f.p. and pressure for ten different skin areas. Each point is the mean of 50 measurements, 5 from each of 10 subjects.

of the skin, consists of the lower lip, tongue, thumb, and finger tip. The bottom cluster, representing on the other hand poorer discriminatory ability, consists of the back of the hand, forearm, upper arm, cheek, fore-

head, and neck. The mean separation of the two groups of curves is 15.4 bursts per second.

Table I shows the sensitivity (discriminatory ability) and variability of ten different skin areas in c.f.p. units. It can be seen that the lower lip is the most sensitive with an average c.f.p. value of 47.9 bursts per second and the upper arm the least sensitive with an average c.f.p. value of 26.5 bursts per second. There are statistically significant differences between the c.f.p. values of any two skin areas except the neck and cheek where the average difference is only 0.2 bursts per second ($t = 0.20$, $p > .05$). In general, each subject shows a rank order of sensitivity similar to the average for the group. Thus when rank-order correlations are calculated between individual orders of sensitivity and the average order of sensitivity, Rhos of 0.57 to 0.99 are obtained. Table I also shows

TABLE I

SENSITIVITY AND VARIABILITY OF TEN SKIN AREAS IN C.F.P. UNITS (BURSTS PER SECOND)

Skin area	Average c.f.p.	Rank order of sensitivity	Variability S.D.	Rank order of variability
Lower lip	47.9	1	2.21	3
Thumb	46.3	2	2.50	1
Tongue	45.5	3	1.94	5
Finger-tip	41.8	4	2.33	2
Forehead	34.9	5	1.56	8.5
Neck	31.5	6	1.69	7
Cheek	31.3	7	1.56	8.5
Back of hand	29.6	8	2.20	4
Forearm	27.1	9	1.87	6
Upper arm	26.5	10	1.40	10

that the thumb is the most variable in skin sensitivity (S.D. = 2.50) and the upper arm the least (S.D. = 1.40). A correlation between sensitivity and variability yields a Rho of 0.68 indicating that the most sensitive areas of the skin are also the most variable. This relationship may be due, in part, to the presence of tiny uncontrolled movements which occur much more readily in the more mobile, that is, more sensitive regions of the body. Such movements would make it more difficult to determine an exact fusion point.

In the earlier preliminary report mention was made of the large individual differences which exist in the discriminatory ability of the finger tip. Similar differences were found on all ten skin areas measured in the present experiment, for example, on the lower lip the c.f.p. values for the various subjects ranged from 38 to 84 bursts per second at 60 lbs. pressure and from 19 to 49 at 20 lbs. pressure. The individual differences were somewhat smaller on the less mobile parts of the skin, for example,

on the forearm the values ranged from 28 to 46 bursts per second at 60 lbs. pressure and from 16 to 24 at 20 lbs. pressure. On all skin areas the individual differences were larger at the higher pressures than at the lower.

Discussion

One of the main findings of the present investigation is that the curve showing the relationship between c.f.p. and pressure is not a straight line function but rather consists of two limbs. Furthermore, the shape of this curve is essentially the same for all ten skin areas tested. The second limb for some skin areas, however, is not as pronounced as it is for others. This relationship between c.f.p. and pressure is supported by the exploratory work of Allen and Hollenberg (1924) on the finger tip and of Allen and Weinberg (1925) and Bellows (1936) on the lower lip, all of whom reported the presence of two limbs. It should be mentioned, however, that these two limbs may only be characteristic of the medium ranges of pressure used in this and other investigations. The relationship might have been different if very low and very high pressures had also been used.

It is of considerable interest to note that these two limbs are not restricted to pressure but are found in all sense modalities when studied by techniques of intermittent stimulation over middle ranges of intensity. Allen and his colleagues (1923, 1924, 1925, 1927) used the flicker method in studying the senses of vision, hearing, taste, pain, and cold and found that in all cases the relationship between flicker frequency and intensity of stimulation consisted of a curve with two limbs. Crozier (1941) in his measurements of c.f.f. also reported two limbs. Recently Blondal (1957), in studying the sense of smell, also reported two limbs. It would appear, therefore, that the existence of two limbs is a general phenomenon common to all sense modalities when stimulated intermittently over the middle ranges of intensity. Furthermore, it would also appear that the two limbs cannot be ascribed to two kinds of receptors, for example, rods and cones or light pressure and deep pressure receptors, in view of their occurrence in senses other than vision and touch. The results suggest that the change of slope represents some general property of the sensory systems in which there is some critical intensity of stimulation in each sensory system at which the rate of response to intermittent stimuli suddenly increases or decreases.

In the present study it was also found that the subjects showed better discriminatory ability on the more mobile areas of the body than on the less mobile areas. Thus the c.f.p. values were higher on the lower lip, thumb, tongue, and finger tip than they were on the upper arm,

forearm, back of the hand, cheek, neck, and forehead. These results confirm those reported by Bellows (1936), who, in some exploratory experiments, found higher c.f.p. values for the lips than for the arms, neck or back. The present results, in general, are also in keeping with those obtained by the classical two-point threshold method where the more mobile skin areas are found to be more sensitive than the less mobile ones. The physiological basis of this difference in discriminatory ability is undoubtedly related to differences in receptor concentration. It is well known that tactual receptors are much more numerous per unit area in the lip, tongue, and finger tip than in such areas as the arms, face, and neck.

Summary

A "flicker" technique, employing an interrupted stream of air whose frequency is increased until a constant sensation of pressure occurs, was used to measure the discriminatory ability of ten different skin areas, viz., tongue, lip, cheek, forehead, neck, tip of index finger, thumb, back of hand, forearm, and upper arm. The curve showing the relationship between c.f.p. or the frequency at which fusion occurs and pressure was found to consist of two linear limbs. The shape of the curve was essentially the same for all ten skin areas tested. The discriminatory ability of the more mobile areas of the body, e.g., lip, tongue, and thumb was superior to that of the less mobile areas such as the arms, neck, and cheek.

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RECOGNITION BY CHILDREN OF REALISTIC FIGURES PRESENTED IN VARIOUS ORIENTATIONS[1]

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It is generally believed (for example Vernon, 1954) that recognition of a mono-oriented realistic figure (that is, a figure that has a usual, or right-side-up orientation) is markedly influenced by its orientation in adults, but not in young children. The experiment reported here was specifically concerned with testing the assumption with respect to children; in addition, the results have some bearing on the role of orientation in the perception of adults.

Surprisingly enough, there does not appear to be any published evidence actually demonstrating that young children recognize an upside-down figure as easily as a right-side-up one. Perhaps the idea that forms are equally identifiable in different orientations by young children has been accepted because it is commonly observed that children look at books, make drawings, or write letters in unconventional orientations. Such observations have been interpreted in the context of the Gestalt assumption that perception of form is unitary and primary; from this point of view, one would anticipate that the young child, who presumably has not developed strong visual habits, would recognize a form equally well in any position. However, Hebb (1949) has suggested that form perception requires the prior development of visual habits; from this point of view, one might suspect that recognition of form in the young child would be particularly dependent on the familiar orientation. This theoretical issue emphasizes the need for obtaining precise information on the role played by orientation of form in recognition.

Hunton (1955) has investigated the problem by analysing the descriptions of right-side-up and inverted realistic pictures given by children of two to fourteen years of age. The children of two to seven years gave fewer descriptions of actions and of relationships between objects for the upside-down pictures than for the right-side-up pictures, indicating that the response to a picture was dependent on its spatial orientation for the younger children. However, it might be argued that the response studied

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depended on recognition of the relations between forms and not on recognition of the form itself. The following study was undertaken to compare directly the ease of recognition of single pictures of familiar mono-oriented figures presented in varying orientations.

Procedure

The Ss were 69 children between the ages of three and seven years who were at a Day Care Center[2] for children of working mothers. There were 15 children at 3 years, 22 at 4 years, 19 at 5 years, and 13 at 6 and 7 years, with an approximately equal number of boys and girls in each age group.

Realistic figures in various orientations were presented tachistoscopically on a screen to each S, and he was asked to name, or point to, the picture he had just seen from an array of pictures present on the screen throughout the procedure (Figure

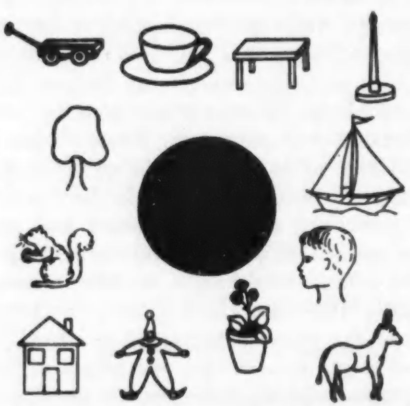

Figure 1. Array of multiple-choice figures. The array was 8¾ in. on a side, and the black circle, where the test figures were presented, was 2¾ in. in diameter.

1). Light conditions were kept constant by darkening the window with black blinds, the only light in the room being that provided by projection of the array of figures on the screen. The S sat approximately 15 feet from the screen, and, before testing began, named each of the pictures in the array. The S was told that he would be shown some of the pictures on the screen, that they would go by very quickly, sometimes upside-down, sometimes right-side-up, and sometimes turned to the side, and that he was to see if he could tell which picture it was. Each time before the picture was exposed, S was told to look at the black circle where the figure appeared. The

[2]The author would like to thank the Director and teachers of the Bronx River Child Care Center for their co-operation and interest.

S then named the picture he had seen, although in a few instances, he came up to the screen and pointed to the picture.

One or more training sessions were required to acquaint S with the procedure, and to find an exposure-duration suitable for presentation of the test figures. The desired exposure-duration was the one at which S would identify approximately half the items; in this way, the general level of difficulty would be comparable for the various age groups. The amount of time spent in training varied from S to S, and was, in general, inversely related to age. The figures used in the training procedure were the house, squirrel, and face (Figure 1), and they were presented in each of the orientations used for the test figures.

The four test figures were the boat, clown, horse, and wagon (Figure 1), and they were presented in each of four orientations—right-side-up, upside-down, rotated 90° to the left, and rotated 90° to the right. The order of presentation of the orientations and the figures was balanced in a Latin square; each S was given the four "replications" and the order of the "replications" was balanced in each age-sex grouping. A second multiple-choice array, consisting of the same figures as the first (Figure 1) in different positions, was introduced half-way through the test procedure to provide variety and to decrease any tendency to select a figure on the basis of its spatial position.

Since tachistoscopic studies with Ss in this age range have not been reported before, it might be added that such work was difficult with children under five years. However, lollipops at the end of each training session did much to keep the Ss' good-will, and it was possible to use all the available Ss except three. These children, two of three, and one of four, years of age, could not sustain attention long enough to complete a session comprising the 16 test figures.

Results

Presentation of mono-oriented realistic figures in the right-side-up position markedly facilitated recognition in the young subjects, and showed a decreasing influence on recognition in older subjects. The effect of orientation can be seen most clearly by considering the number of correct responses for each orientation relative to the total number correct for the age group (Figure 2), since the absolute levels of performance varied somewhat in the different age groups. If recognition were equally good for each of the four orientations, then each orientation would contribute 25 per cent of the total number of correct responses. In the youngest group, more than 40 per cent of the correct responses were for the right-side-up figures, whereas the three groups of disoriented figures each added approximately 20 per cent of the correct responses. Thus, twice as many items were recognized in the right-side-up orientation as in any of the other orientations by the three-year-old children; the facilitating effect of the familiar orientation decreased in an almost linear fashion from the third to the seventh year of age.

The mean scores for each condition were compared by an analysis of variance for each age group. As might be anticipated from Figure 2, the

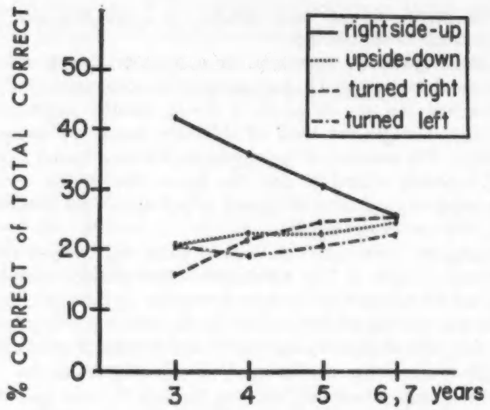

FIGURE 2. Proportion of correct responses contributed by each orientation at various ages. The total number of correct responses was 7.0 at 3 yrs., 6.2 at 4 yrs., 6.3 at 5 yrs. and 8.9 at 6 and 7 yrs., the maximum score possible being 16. The mean number of correct responses for each orientation can be computed from the total scores and percentages given above.

F ratio for orientation was highly significant in the groups of three and four years of age, fell somewhat short of the .05 level in the five-year-old children, and was negligibly small in the group of six and seven years of age (Table I).

Although the main concern of this experiment has been the relative performance under varying conditions, two observations on the absolute level of performance have been made that are relevant to tachistoscopic studies in general. First, it was necessary to use slower exposure-durations in the younger than in the older groups. The median exposure-durations (and ranges) for the groups of 3, 4, 5, and 6–7 years were, respectively, 100 msec. (20–500 msec.), 20 msec. (10–200 msec.), 5 msec. (5–40 msec.)

TABLE I

ANALYSES OF VARIANCE FOR THE DIFFERENT AGE GROUPS

	3 years			4 years			5 years			6 and 7 years		
Source	df	MS	*F*	df	MS	*F*	df	MS	*F*	df	MS	*F*
Orientation	3	9.71	13.77**	3	4.32	5.33*	3	1.45	2.69	3	0.27	<1
Subjects	14	0.89	1.27	21	1.03	1.27	18	2.94	5.44	12	4.99	10.94
Residual	42	0.71		63	0.81		54	0.54		36	0.46	

*p <0.01 **p < 0.001.

and 5 msec. (5–40 msec.), with the mean exposure-duration being longer in the five-year-old group than in the oldest group. Although one might intuitively expect that young children would require longer exposure-durations than older children, there does not appear to be any ready explanation for this difference. Second, the absolute scores were compared in boys and girls, matched for exposure-duration, since other work had revealed some sex differences on perceptual tasks in this age group (Ghent, in press). The boys in the five- to seven-year age range recognized significantly more pictures than did the girls ($t = 2.76$, $p < .01$), but there was no difference between boys and girls in the three- to four-year age group. These data suggest the need for further comparison of the sexes in tachistoscopic form perception.

Discussion

It was found that young children were markedly dependent on the familiar orientation for recognition of realistic figures, and that older children showed no such dependence. One might argue that presentation of the multiple-choice array only in the right-side-up position facilitated identification of the figures in that position preferentially for the young children. However, other work has shown that identification (by preschool children) of tachistoscopically presented geometric figures is no better when the stimulus and multiple-choice figures are in the same orientation than when these figures are in different orientations (Ghent & Bernstein, in press).[3] The discussion will deal, first, with the apparent disagreement of the two main findings with previous work, and second, with a possible mechanism whereby a familiar orientation could enhance recognition in the young child and could decrease in effect with age.

The young child's dependence on orientation for recognition is not, as one might first think, in contradiction to the finding that young children do not match the orientation of forms in a multiple-choice situation

[3]Even without these data, it would be difficult to see how the orientation of the array could be responsible for the better identification of right-side-up figures by the young Ss. It cannot be claimed that the young Ss had difficulty in equating the disoriented stimulus figures with the right-side-up figures in the multiple-choice array since young children spontaneously match forms differing in orientation, and appear, in fact, to be unable to match orientations (see discussion). It might, at first sight, seem possible that an S would try to match indistinctly perceived portions of the stimulus figure with portions appearing to be in the same position in the array, and such comparisons would provide useful cues when both stimulus and array figures were in the same orientation; this possibility is unlikely since it is difficult to understand why recognition in the older Ss would not be facilitated as well. Moreover, the array was 15 ft. away from S and he usually named the item.

(Rice, 1930; Davidson, 1934) or in copying forms or letters. These observations indicate only that the child is not able to match the relation between a form and its framework with the relation between another instance of the form and its framework. This inability to match orientations has been conceived of as a lack of concern with orientation, and has led to the unwarranted assumption that a form "looks the same" to the child in all orientations and hence can be recognized equally readily in any orientation. Mouchly's finding (unpublished) that the orientation of items did not affect the speed with which children found the two identical items in a group, whereas the speed of adults was affected, could also be due to the child's inability to match the orientation of forms. In looking for the two identical items, the adult would presumably look for identity of both shape and orientation, whereas the child would seek only identity of shape since he appears to be unable to find identity of orientation. The child's speed of selecting the forms thus would be relatively unaffected by the identity, or lack of it, of orientation of the forms. Without doubt, the orientation of a form does not influence the matching behaviour of the young child, but the data reported here indicate that orientation does affect recognition in the young child.

The lack of effect of orientation on recognition in the older child stands in direct contradiction to the finding of Gibson and Robinson (1935) that adults recognize right-side-up realistic figures markedly better than they recognize disoriented ones. These discrepant results may be due to a procedural difference. In the experiment of Gibson and Robinson (1935), the subjects did not know that the figures would sometimes be disoriented 90° or 180°, whereas in the study reported here, the subjects had this information. It is likely that, in the absence of information to the contrary, the subject would assume that the figures would be in the right-side-up position, and this implicit set, rather than the nature of previous experience *per se*, could be responsible for the difficulty in recognizing disoriented figures. This interpretation is supported by Hunton's finding (1955) that there was no difference in the descriptions of right-side-up and inverted pictures after seven years of age; in Hunton's study the children also knew that some pictures were upside-down.

Now let us consider a mechanism that could account for the influence of a familiar orientation on recognition in the young child. Although some type of experiential factor certainly plays a role, it is clear that more than a simple kind of learning is involved, since continued experience (as the child get older) is associated with a decrease in the facilitating effect of the familiar orientation.

The explanation proposed here rests on two main assumptions. First, perception of form is not immediate in the early stages of development,

but the individual scans the form by looking first at one portion and then at another, as Hebb has suggested (1949). Second, there is a tendency, at least in young children, for this sequential consideration of a figure[4] to proceed in a top-to-bottom direction, as suggested by other work (Ghent, in press). Mono-oriented realistic figures would, therefore, be regularly perceived in the same sequence, since such figures appear in a particular orientation in the environment and it is assumed that young children scan these forms in a constant direction. The facilitating effect of a familiar orientation on recognition could result, then, from a congruence between the sequence of perceptual events relating to the test figure and the sequence of perceptual events relating to similar figures observed on previous occasions. In Hebb's terms, a set of cell-assemblies would be more readily aroused when the incoming pattern is such as to arouse the cell-assemblies in the same sequence in which they were organized.

The decreasing effect of the familiar orientation on recognition as the child grows older could occur in a number of ways. One possibility is that scanning a figure is no longer limited to a particular direction. Another possibility (and perhaps the more likely one) is that perception of only a portion of a figure becomes increasingly adequate for identification of the figure. If, for example, it is as easy to identify the human figure from the legs as from the head, then the orientation of the form would be irrelevant for recognition under ordinary circumstances. However, on the assumption that scanning persists in the adult, orientation could be a factor in recognition under special circumstances. Since scanning in a top-to-bottom direction would tend to facilitate perception of the upper portion of the figure, recognition would be better when the elements providing the basis for recognition occurred in the upper rather than the lower portion of the figure. For example, one would predict that an adult would be more likely to distinguish a woman and a mermaid when their pictures were presented in the upside-down orientation than when they were presented in the right-side-up orientation!

Orientation has been thought to play a role in form recognition only through the medium of familiarity. On this basis, it has been said that the orientation of realistic figures is unimportant to the young child, but as the child has repeated experiences with figures in particular orientations, he becomes more dependent on the familiar orientation for recognition of the figure. Paradoxically, the situation appears to be the reverse—the familiar orientation influences recognition in the young, but not the older, child. The particular explanation offered for these data involves several

[4]The terms, "sequential consideration of a form" and "scanning," will be used synonymously, and are meant to refer to a central motor process facilitating perception.

assumptions regarding the process of form perception in the young child, and changes in this process with age. The implication of this line of thought is that orientation may influence recognition in several ways, of which familiarity is only one. It has already been found that the orientation of certain geometric forms influences recognition in young children (Ghent & Bernstein, in press), and, as suggested above, it may be that recognition in the adult would be affected by the particular part of a figure that is placed in the upper portion.

Summary

It is generally believed that recognition of a mono-oriented realistic figure is markedly influenced by its orientation in adults, but not in young children. The experiment reported here was specifically concerned with testing the assumption with regard to children; in addition, the results have some bearing on the role of orientation in the perception of adults.

Mono-oriented realistic figures were presented tachistoscopically in each of four orientations–right-side-up, inverted, turned 90° left, and 90° right–to children between the ages of three and seven years. The Ss of three and four years recognized significantly more figures in the right-side-up position than in any of the other positions; the older Ss recognized the figures equally well in the various orientations in which they were presented. The discussion dealt, first, with the apparent contradiction of both these findings with previous work, and second, with a possible mechanism whereby familiarity could enhance recognition in the young child and decrease in effect with age.

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FEEDBACK DURING TRAINING AND RETENTION OF MOTOR SKILLS[1]

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As support for his Law of Effect, Thorndike (1927, 1932) leaned heavily upon data from experiments involving simple motor skills. In one experiment blindfolded subjects were instructed to draw 3-, 4-, 5-, and 6-inch lines, 150 of each per day, for nine days. On the first or pre-training day no information was given concerning accuracy of performance. In each of seven subsequent days the experimenter said "right" or "wrong" after each line, depending on whether or not the length of the line was within arbitrarily chosen tolerances. On the ninth or post-training day all feedback was again withheld.

On the pre-training day about 13 per cent of the lines were within tolerance limits. On the first training day there was a marked improvement which continued, though in smaller increments, throughout the remainder of the seven-day training period: on the last training day 54 per cent of the lines were "correct." On the ninth day feedback was no longer given and a dramatic drop in performance resulted: only 25 per cent of lines were the correct length. A control group of subjects given no feedback showed no improvement in performance over the nine days.

Thorndike (1927) did not discuss this sudden drop in performance other than to point out a "striking feature . . . the great discrepancy between the ability under the immediate guidance of the announcements of 'right' and 'wrong' and the ability after these cease." Concerning the improvement with feedback he noted that "the improvement consists in the reduction of constant errors rather than variable errors." (1932, p. 192)

Thorndike's experiment was the first of a series reported by various investigators which revealed a marked drop in performance when feedback was no longer presented. The literature has been reviewed by Ammons (1956). Without known exception none of these experiments has studied performance for prolonged periods after feedback was denied. Thus, while the performance of Thorndike's subjects dropped to 25 per cent correct on the ninth or "test" day, we have no information concerning their performance on a tenth, an eleventh, or a twelfth day.

The experiments reported here were undertaken to determine the nature of performance in a simple motor task over relatively long periods

[1]Defence Research Medical Laboratories Report no. 241-2, DRML Project no. 241, PCC no. D77-94-01-16, H.R. no. 191.

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of feedback denial, that is, over periods at least as long as those employed in training with feedback.

Experiment I

The technique employed was a modification of that used by Thorndike (1927). Blindfolded Ss sat facing *E* across a table on top of which was fixed, by screws at each end, a ¼-in. sheet of perspex. An 18-in. slot, ⅜ in. wide, was cut through the perspex parallel to the edge of the table, and the end of a long sheet of graph paper, 12 in. wide and ruled 10 to the inch, was slid under the perspex so that it could be grasped by *E*. When each line was completed *E* lifted S's hand and returned it to the starting point, at the same time easing the paper towards *E* to ensure that the next line would not cross the previous one. Lines were always drawn from left to right.

A 4-in. block of wood was mounted on the table near the left end of the perspex and also parallel to the table edge. While Ss inscribed lines with the right hand the left hand was in continual contact with the block. They were never permitted to see the block nor were they told how long it was: their instructions were simply to draw lines as long as the block.

Four groups of Ss were employed, each member of each group inscribing 200 lines per day. Except where Saturdays and Sundays intervened, experimental days were successive. Error feedback was the same as that used by Thorndike, that is, a statement of "right" or "wrong" depending on whether or not the line length was within the tolerance limits. Our tolerance limits were slightly smaller than Thorndike's, being ± .20 in. rather than ± .25 in. Lines were inscribed in blocks of 20 at a rate of about one line every five sec. A half minute rest pause was given between blocks. The completed experiment consisted of 84,000 lines.

Treatments[2] for each of the four groups were as follows:

1. One pre-training day, one day with feedback (FB), and three post-training days, using 12 paid Ss.
2. One pre-training day, four days with FB, and five post-training days, using another 12 paid Ss.
3. One pre-training day, seven days with FB, and seven post-training days, using another 12 paid Ss.
4. Ten days without FB, as a control, using another six paid Ss.

Results

Levels of Performance

The results are shown in Figure 1 in terms of the percentage of "correct" line lengths as a function of days. Thorndike's data (1927, Table 4) have been plotted in Figure 1 for comparison.

In addition an analysis of variance was made of the data for the pre-training day and the first three post-training days of the three experi-

[2]The experimental plan was, in part, dictated by subject availability. In the two experiments reported here 54 subjects were employed for a total of 560 individual experimenter-subject sessions.

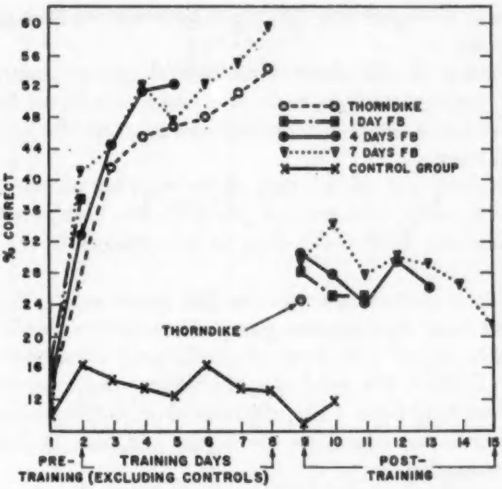

FIGURE 1. Showing the percentage of lines drawn to the correct length on a pre-training day, on training days, and on post-training days for the three experimental groups and the control group. Thorndike's data have been included for comparison.

mental groups, using an arcsin transformation of the percentage of lines drawn the correct length—see Table I.

The points to be noted from Figure 1 and Table I are as follows:

1. Performance of the control group showed no evidence of improvement over 10 days.

TABLE I

ANALYSIS OF VARIANCE

Source	df	MS
Between Subjects	35	
Between Groups	2	0.1628
Error	33	0.5195
Within Subjects	108	
1 Day Pre-training vs First 3 Days Post-training	1	3.2622**
Differences Between 3 Post-training Days	2	0.1691
Days × Groups	6	0.0980
Remainder	99	0.1708

**Significant at the .01 level of confidence.

2. There was no significant difference between the four groups on the pre-training day.

3. Performance of the three experimental groups improved during training, the improvement in each case being significant by inspection. Further, there was a direct relation between amount of improvement and amount of training.

4. After termination of training there was an abrupt drop in the performance of each experimental group on the first post-training day. A separate analysis showed this drop to be apparent in the very first 20 lines drawn.

5. The drop in performance on the first post-training day was to the same level for each experimental group. The analysis shows this level to be significantly higher (.01 level of confidence) than that on the pre-training day. Further, this level of performance was maintained throughout the post-training days. (The apparent drop in the case of the seven-day FB group is not significant by a sign test, due to the great variability in performance.)

6. In terms of pre-training level of performance, of increments in performance while training, and of the abrupt drop in performance on the first post-training day, these data are indistinguishable from those reported by Thorndike.

Direction of Error

The data above concern percentages of line lengths which were within arbitrarily chosen tolerance limits and give no indication of the actual lengths of lines. Figure 2 shows the average length of line drawn by each group each day. Each point for the control group represents the mean length of 1200 lines, while each point for each experimental group represents the mean length of 2400 lines. From Figure 2 it is apparent that except for the seven-day FB group the average line length on the pre-training day was short of the tolerance limits. The high value for the seven-day FB group was due to two subjects whose average line lengths on the pre-training day were the longest of all 42 subjects. The exclusion of these two subjects would result in an average length of 3.4 rather than 3.9 inches.

On all training days the average line length was within tolerance limits. However, on post-training days the marked drop in percentage of correct line lengths (Figure 1) was the result of a tendency to draw still longer lines in the case of the one-day FB group, and a tendency to revert to shorter lengths in the case of the other two groups. The lines drawn by the control group were consistently short.

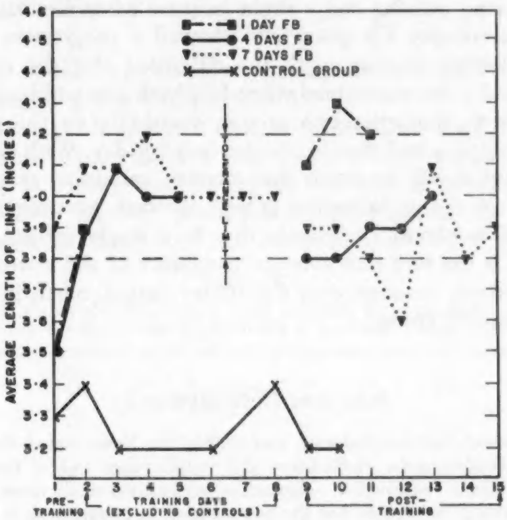

FIGURE 2. Showing the average lengths of lines drawn on a pre-training day, on training days, and on post-training days, for the three experimental groups and the control group.

Daily Subject Variability

The improvement in line length with feedback can be considered as a decrease in the constant error. To determine whether there was a change in variability also, the average interquartile ranges of lengths of line were computed for each subject day and group, and are given in Table II.

The average variability of the one-day FB group was quite constant over all five days and that of the four-day FB group showed a progressive

TABLE II

AVERAGE INTERQUARTILE RANGES (INCHES) OF LENGTHS OF LINE FOR EACH GROUP ON EACH DAY

Group	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Day FB	6.5	$\underline{6.6}$*	7.1	6.0	6.0										
4 Day FB	9.0	$\underline{7.7}$	6.5	5.4	5.3	6.3	6.0	6.4	6.4	6.0					
7 Day FB	8.3	$\underline{7.3}$	$\underline{6.2}$	$\underline{6.2}$	$\underline{5.7}$	$\underline{4.6}$	$\underline{4.5}$	$\underline{4.3}$	5.3	4.2	4.7	4.3	4.7	4.3	5.2
Control	4.6	4.6	4.0	5.0	4.5	3.8	4.1	4.1	3.8	3.4					

*The underlined values denote days on which error feedback was given.

decrease during training and a slight increase when feedback was withheld. The seven-day FB group also showed a progressive decrease in variability during training, with the difference that the reduced variability tended to be maintained when feedback was withheld. In general with respect to the latter two groups, variability on the post-training days never approached that of the pre-training day. With respect to the control group it will be noted that average variability was lower than that of any of the experimental groups on their pre-training day. This low average is almost completely due to a single subject. Of greater importance is the fact that average variability of the control group remained relatively constant over the 10-day period, much in the manner of the one-day FB group.

Summary (Experiment I)

This experiment has demonstrated that within the limits tested the abrupt and marked deterioration in the performance of a simple motor task of the type studied here when feedback is denied is independent of the amount of training with feedback. In addition it has shown that the deterioration in performance is not complete, a residue of skill remaining over a period at least as long as that consumed in training.

Performance during pre-training was characterized by a negative constant error. The data suggest that after feedback denial the deterioration in performance reflects a positive constant error when the training has been relatively slight, but a reversion to a negative error after more prolonged training. In general, performance variability was reduced during training, the longer the training period the greater the tendency for the reduced variability to be maintained during the post-training period.

Experiment II

In Experiment I we demonstrated that the common level of performance to which all groups dropped on the first post-training day, and maintained, occurred whether or not the training period resulted in a modification of variable errors; that is, post-training performance was, as for Thorndike, the consequence of a decrease in the constant error and independent of any change in the variable error. Consequently, training with feedback aimed at achieving retention of skill after feedback is denied might better be aimed at minimizing the constant rather than the variable error. One way of doing this is to give feedback only after blocks of responses have been completed.

To test this proposal a fourth experimental group of 12 subjects was employed in a way similar to the four-day FB group above, that is, one day pre-training, four days training, and five days post-training. During the four days training feedback was given in a novel way: instead of stating "right" or "wrong," the experimenter wrote R or W in a column on a card after each line was completed. At the end of each block of 20 trials the subject was allowed, during the half-minute rest, to examine for the first time the card displaying 20 R's or W's arrayed in a column.

Results

The results of this experiment are contrasted in Table III with those of the four-day FB group of Experiment I.

From Table III it is apparent that, as for the four-day FB group, and the other experimental groups of Experiment I, there was a considerable improvement in performance during the first day of training. Improvement with further training, however, was negligible. On the other hand performance of the two groups was equivalent on the first post-training day, this being the consequence of a significant drop in the case of the four-day FB group and a negligible drop in Experiment II. In later post-training days, however, performance in Experiment II continued to decline to the level of that on the pre-training day whereas there was a small but significant saving in the case of the four-day FB group.

TABLE III

Average Percentage of Lines Drawn the Correct Length on Each of 10 Days by the Four-Day FB Group of Experiment I, and the Group in Experiment II

	Pre-Training	Training Days				Post-Training Days				
	1	2	3	4	5	6	7	8	9	10
Experiment I	15	33	45	52	53	31	28	24	30	26
Experiment II	18	33	38	36	36	31	26	19	22	15

Discussion and Conclusion

The results of these experiments suggest that learning of simple motor skills is a dichotomous phenomenon. Early in training one learns the approximate limitations of the type of response required: in the terminology used above one learns the sign of the constant error and makes gross adjustments in the appropriate direction. We can characterize this as Phase 1 learning. Phase 1 learning, besides occurring early, is retained over long periods of time, possibly because it involves so gross an adjustment as to be remembered with ease.

Supporting evidence that learning which occurs early in training is retained is found in the data reported by Bilodeau *et al.* (1959) on a lever positioning task. One group was given quantitative directional feedback on the first two trials only. On the third trial the average error was 5⅛ units while that of the control (no FB) group was 11 units. On the twentieth trial the error of the experimental group was only seven units. As these investigators say, their data "do not suggest an imminent regression to the level of the initial error."

We suggest that in the case of our line drawing experiments Phase 1 learning was completed by all groups within the first day of training.

Subsequent learning with feedback (Phase 2) results in further improvement by gradually reducing response variability, that is, by channelling more and more responses to within the tolerance limits. Feedback during Phase 2 serves as a reinforcement for correct responses, thereby increasing their probability of repetition, that is, serves to make differences in line length just noticeable whereas they are indiscriminable when feedback is not given. Support for this position comes from Blackwell's (1953) studies of brightness discrimination thresholds. "Subjects . . . given immediate knowledge of the correctness of each response . . . [showed] . . . a learning effect and the low thresholds obtained . . . [were in] . . . striking contrast with the data for the group of subjects . . . without knowledge of results." (pp. 166–7)

The consequence is that when feedback is withheld the finer discriminations cannot be made and performance immediately falls to that level achieved early in training, and remains at that level for some time.

This position is completely adequate in explanation of the results of Experiment I but only partially so in the case of Experiment II. On the positive side we point to the fact that in Experiment II there was improvement in performance on the first day of training and that as no feedback was given following individual responses there was negligible improvement during the remainder of the training period. Further, on the first post-training day the level of performance was indistinguishable from that of the three experimental groups in Experiment I. However, the gradual decline to the original pre-training level of performance remains unexplained and might be interpreted as indicative of a more complex explanation than that offered here. On the other hand, we point to the fact that our feedback was given, quite arbitrarily, after each 20 lines were drawn, and that possibly it should have been given after every five, or after every fifty: an optimum may exist.

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PERFORMANCE IN A VIGILANCE TASK AS A FUNCTION OF LENGTH OF INTER-STIMULUS INTERVAL[1]

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In vigilance situations, where subjects must respond to a sporadically presented stimulus, response latencies increase progressively with task duration (Kennedy & Travis, 1947; Mackworth, 1950; McCormack, 1958; McCormack, 1959). Under such conditions contradictory results have been reported in that response time has been shown to be both a decreasing function of length of inter-stimulus interval (McCormack, 1959) and invariant with it (McCormack, 1958). Since the subjects were females in the former case and males in the latter, the relation between response time and length of interval may be dependent on whether males or females are employed as subjects. The present investigation was designed to test this hypothesis.

Method

Apparatus and procedural details have been described elsewhere (McCormack, 1959). Briefly, S's task was to depress a microswitch immediately after a light was seen. The light was placed 13 ft. from S and appeared for one-tenth of a second. Response time was recorded in millisec. by means of a Hunter Klockcounter. The intervals between stimuli were 30, 45, 60, 75, and 90 sec. The stimuli appeared in a different random order for each S with the restriction that all Ss experience each of the five intervals once every five min.

In the present study, 10 male and 10 female laboratory staff members served as Ss. Each S participated in two 35 min. sessions which were separated by a period of seven days. On both occasions S was told that the experiment would last about one half hour.

Results and Discussion

A summary of an analysis of variance performed on the data is presented in Table I. The analysis represents a combination of two separate factorial analyses, one for each sex. (These were combined only after it was demonstrated that the two error variance estimates were of approximately the same size.) The residual mean squares of Table I were used as error terms in testing the statistical significance of the main effects and each of their interactions.

[1]Defence Research Medical Laboratories Report no. 234-7, P.C.C. no. D77-94-20-42 (H.R. no. 195).

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TABLE I

Analysis of Variance of Response Times

Source	df	Mean Square
Between *Ss*	19	
Sex (X)	1	429.0
Residual	18	112,326.7
Within *Ss*	1380	
Time Blocks (T)	6	21,558.9*
Inter-stimulus Intervals (I)	4	165.9
Replications (R)	1	2.2
TI	24	2,925.8
TR	6	6,575.3
IR	4	607.0
XT	6	1,214.9
XI	4	4,044.1
XR	1	750.4
TIR	24	2,527.4
XTI	24	2,107.0
XTR	6	1,958.4
XIR	4	3,465.4
XTIR	24	3,734.9
Residual	1242	2,837.5
TOTAL	1399	

*$P < .001$.

It is evident from Table I that the only statistically reliable effect was that of time blocks. The relation between response time and task duration was a monotonically increasing one and was consistent with earlier vigilance studies where performance was shown to deteriorate as the experimental session progressed.

The interval and interval × sex effects, if any, were not statistically dependable, indicating that response time was invariant with length of inter-stimulus interval for both male and female subjects. Thus the contradictory findings referred to earlier may not be attributed to differences in the sex of the subjects. In the light of the fact that the present findings are in agreement with an earlier study based on the performance of 60 subjects (McCormack, 1958) but conflict with a later investigation in which only 10 subjects were employed (McCormack, 1959), it is reasonable to conclude that response time is constant for all values of inter-stimulus interval length within the range of those explored to date.

The replications and replications × time blocks effects were not statistically significant. Thus the relation between response time and task duration was constant from session to session. This finding—that subjects behave consistently from day to day—indicates that it might well be fruitful to use each subject as his own control in future studies designed to explore the effects of various variables on the relation between re-

sponse time and task duration. This would avoid having to employ large numbers of subjects in order to achieve the necessary precision for rejecting the null hypothesis when some other hypothesis is more tenable.

An examination was made of the distribution of the mean response times for all subjects about each of the seven time block means. As in earlier studies, there did not appear to be any marked signs of non-normality or heterogeneity. The within-subjects' error mean square of 2837 was of the same order of magnitude as those of 2787 and 3086 previously reported, indicating that all uncontrolled sources of variability had a constant effect from experiment to experiment.

Figure 1 shows a least-squares linear regression fit to a response time versus time function based on this and two earlier studies. Each em-

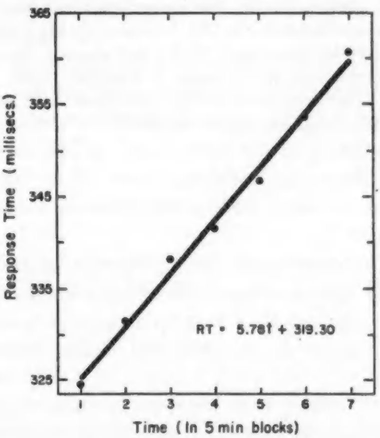

FIGURE 1. Response time as a function of task duration.

pirical point represents 550 measures. It may be concluded from examination of Figure 1 that response time is an increasing linear function of time for at least the first 35 min. of the task.

The findings of the present study have forced the author to alter his theoretical interpretation of vigilance phenomena (McCormack, 1959). The inhibition construct *I* is now assumed to accumulate linearly with time and to dissipate only during periods of interpolated rest. The rate at which *I* accumulates is assumed to be less when knowledge of results is provided than when it is withheld.

Summary

Ten males and 10 females served as Ss in a vigilance task consisting of two 35 min. sessions. S was instructed to press a switch immediately after a light was seen. The light appeared randomly in time with the intervals between presentations being 30, 45, 60, 75, and 90 sec.

Response times showed a significant increase throughout the duration of the task but remained invariant with length of inter-stimulus interval. Both phenomena were consistent from day to day for Ss of both sexes. Data from this and two earlier studies indicate a linear relation between response time and task duration.

The findings of the present study are consistent with the hypothesis that inhibition accumulates linearly with time and dissipates only during periods of interpolated rest.

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MOTIVATION AND THE SPIRAL AFTEREFFECT WITH SCHIZOPHRENIC AND BRAIN-DAMAGED PATIENTS[1]

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THE ARCHIMEDES' SPIRAL IS RECEIVING increasing attention in the current clinical literature as a tool for the detection of brain damage. All investigators agree that brain-damaged persons are significantly inferior to non-organic patients and to normals in their ability to report the spiral aftereffect (SAE) (Price & Deabler, 1955; Gallese, 1956; Page, Rakita, Kaplan, & Smith, 1957; Gilberstadt, Schein, & Rosen, 1958; Berger, Everson, Rutledge, & Koskoff, 1958). The assumption seems to be that the neurological damage makes it physically impossible for the brain-damaged person to experience the phenomenon.

But in all these investigations a minority (the size of which varies with each investigator) of the brain-damaged group report the perception of SAE. And there appears to be little or no relation between the locus of the damage and this ability. In essence, the implication seems to be that damage to any part of the brain makes it physically impossible to perceive the SAE, with some exceptions who show no distinctive neurological patterns.

This suggests that the commonly held assumption of physical incapacity may be at fault. It makes tenable the hypothesis that the characteristically inferior performance of organic groups with the SAE technique is due to psychological factors which are common to many, but not all, brain-damaged persons.

Several investigators have reported that patients with brain damage frequently are anxious (Goldstein, 1936; Goldstein, 1952), have a strong desire to do well (Coons, 1956), and are reluctant to admit physical or mental illness (Weinstein & Kahn, 1950 & 1953; Nathanson, Bergman, & Gordon, 1952). These observations suggest that, when exposed to the apparently bizarre SAE, many brain-damaged patients refrain from reporting what they experience because they are afraid that they may be labelling themselves as mentally ill, or at least, as queer.

If this is so, brain-damaged patients whose anxiety is allayed by assurance at the outset that the SAE is normal should not be inferior in frequency of report to non-organic patients. Similar reassurance to non-

[1]Based on a dissertation submitted by E. Mayer in partial fulfilment of the requirements for the Master of Arts degree at the University of Toronto. The authors are indebted particularly to Dr. J. N. Senn for his support of the study.

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organic mental patients who are not characteristically anxious, should have little or no influence on the frequency of SAE report.

The present study is designed to test these hypotheses by comparing the performances of groups of organic and functional mental patients under conditions imbued with varying amounts of reassurance.

Method

Apparatus

An Archimedes Spiral of 2⅜ turns about the centre was painted in black on a white cardboard disk 12 in. in diameter. A reversed spiral was constructed for the effect of opposite rotation. An electric variable speed motor and stand commonly employed in colour mixing experiments was used to produce the necessary rotation of the spirals. The speed of rotation was set at approximately 100 r.p.m. for the entire experiment. Rotation of the spirals was started and stopped by means of a switch; the stopping lag was approximately 1 sec. Ss were seated 8 ft. from the apparatus and spirals were presented at eye level.

Procedure

Testing was conducted only in the day-time when illumination was optimal. The same setting was used throughout the experiment and Ss were tested by the same *E*. *S*s wore their glasses if required.

Preliminary to presentation of the spiral task, Ss were given the Information subtest of the Wechsler Adult Intelligence Scale, in order to obtain a rough estimate of their level of intellectual functioning. In addition, to ensure that Ss could conceptualize relative size, they were shown two circles of unequal size and asked to identify the larger.

The spiral task was then introduced. Preceding the actual test standard instructions were given as follows:

(1) *Reassuring instructions*: "Do you see the spiral? I am going to make it turn around. While it is turning and when it stops, most people see something strange happening to it. Look at it while it is turning, and tell me what *you* see happening to it as it turns and when it stops."

(2) *Anxiety-producing instructions*: "Do you see the spiral? I am going to make it turn around. While it is turning and when it stops, some people in hospital because of their illness see something strange happening to it. Look at it while it is turning, and tell me what *you* see happening to it as it turns and when it stops."

(3) *Neutral instructions*: "Do you see the spiral? I am going to make it turn around. Look at it while it is turning and tell me what you see happening to it as it turns and when it stops."

Immediately preceding rotation, *E* pointed to the centre of the spiral with the following instructions: "Look at this centre here. Keep looking at it while the spiral is turning and do not take your eyes off it." The spiral was then set into motion and rotated for a total of 30 sec. After 10 sec. rotation S was asked: "What does the spiral seem to be doing now?" This was done to make sure S was attending and could report his experience. During the rotation, instructions were given repeatedly to: "Keep looking at the centre of the spiral. Do not look away." Just prior to stopping the disk, *E* said: "I am going to stop it now. Keep looking at the centre and do not take your eyes off it when it stops. Tell me what the spiral seems to be doing

when it is stopped." The spiral was then stopped and Ss were asked immediately: "What does the spiral seem to be doing now?" The patient's answer was recorded verbatim.

Spiral A, resulting in an aftereffect of contraction, and Spiral B, giving an aftereffect of expansion, were presented twice each for every S in the order of ABBA or BAAB for a total of four exposures per subject.

Any response which indicated that S experienced a negative aftereffect of expansion or contraction with the appropriate spiral was considered evidence for success on a particular trial, for example, "coming towards me," "getting smaller," etc. Responses indicating failure on a trial were for example: "standing still," "stopped," etc. Any S reporting the correct aftereffect on at least three of four trials was considered successful.

Subjects

The *organic* group consisted of 30 patients (21 male and 9 female) with diagnosed brain damage. These Ss included cases with CNS syphilis ($N = 18$), post-traumatic encephalopathy ($N = 2$), Huntington's Chorea ($N = 4$), Parkinson's Disease ($N = 3$), cerebral vascular accident ($N = 1$), meningitis ($N = 1$), and cerebral atrophy ($N = 1$).

Thirty patients (21 male and 9 female) diagnosed as paranoid schizophrenics constituted the *functional* group. All the functional patients were considered free from any pathology suggestive of organic brain damage. Because electro-convulsive and insulin coma treatments produce temporary organic effects (Kalinowsky, 1945; Stone, 1947), no patients who had been subjected to such treatment shortly prior to, or at the time of, testing were included in the study.

Due to the importance of adequate verbalization in reporting the aftereffect experience, unco-operative or incoherent Ss were not considered testable. Patients with gross visual defects were excluded.

The organic and the functional Ss were roughly comparable with respect to age, intelligence, and educational level. Due to the possibility of organic deterioration in old age, Ss over 60 years of age were not considered suitable for this experiment. No S functioning below an IQ level of 70 was included in the sample.

Ten Ss from the functional and organic groups were assigned to each of the three instruction subgroups. Five Ss were shown the spirals in the order ABBA, and five Ss in the order BAAB in each instruction subgroup.

Table I presents a comparison of the organic and functional groups, as well as of the six instruction subgroups on the variables: age, intelligence, education, and length of hospitalization.

TABLE I

AGE, IQ, EDUCATIONAL LEVEL, AND LENGTH OF HOSPITALIZATION OF FUNCTIONAL AND ORGANIC PATIENTS

	Functional Group				Organic Group			
	Instruction Subgroup				Instruction Subgroup			
	I	II	III	Total	I	II	III	Total
Mean age	49.2	48.2	53.1	50.2	47.8	50.0	51.8	49.9
Mean IQ	93.8	96.3	91.5	93.9	87.0	91.8	87.7	88.8
Mean yrs. of schooling	7.8	9.0	8.4	8.4	7.1	8.2	7.5	7.6
Mean yrs. of hospitalization	13.1	13.4	17.9	14.8	5.1	6.1	10.9	7.4

TABLE II

FREQUENCY OF AFTER-EFFECT (SAE) REPORT IN FUNCTIONAL AND ORGANIC SUB-GROUPS UNDER THE 3 INSTRUCTIONAL CONDITIONS

Type of instruction	Response	Diagnostic group		Level of significance*
		Functional	Organic	
Reassuring	SAE reported	6	5	N.S.
	SAE not reported	4	5	
Anxiety-producing	SAE reported	8	2	0.025
	SAE not reported	2	8	
Neutral	SAE reported	8	1	0.005
	SAE not reported	2	9	

*Fisher Exact Probability Test.

RESULTS

The 3 functional subgroups combined reported the SAE significantly more frequently than did the 3 organic subgroups combined ($\chi^2 = 13.07$; $p < .001$).

The effects of the instructional variables are summarized in Table II.

(1) Under the reassuring instructional condition, functional and organic groups were not significantly different in frequency of SAE reporting.

(2) Under the anxiety-producing instructional condition, the organic group reported the SAE significantly less frequently than did the functional group.

(3) Under the neutral instructional condition, the organic group behaved as it did under the anxiety-producing instructions.

(4) The functional groups showed no significant response to the manipulation of the instructional variable ($\chi^2 = 1.38$; $p > .50$).

DISCUSSION

The results indicate that reassurance had a striking influence on the frequency with which the organic patients reported experiencing the SAE. With reassurance, the organic group reported the SAE approximately as frequently as did the schizophrenic group. The schizophrenics, on the other hand, showed no significant response to the manipulation of the instructional variable. These findings suggest that the inability to report seeing the spiral aftereffect is not, at least primarily, a neurophysiologically based disability. If it were, variations in instruction would have no impact on the frequency of aftereffect report in brain-damaged patients.

Thus, our explanation in psychological terms is supported: the anxiety

which is characteristic of brain-damaged patients leads them to deny seeing the seemingly abnormal SAE unless steps are taken to assure them of its normal nature. The essentially similar results with the organic patients subjected to the neutral and to the anxiety-producing instructions supports this contention. Because of the organic patient's basic anxiety it is not enough to avoid threatening him. Unless positive steps are taken to reassure him, he feels threatened all the time and acts in ways designed to reduce the threat. In the spiral aftereffect situation in a hospital for mentally abnormal people the threat-reducing behaviour is failure to report "incriminating" experiences. As yet there is no evidence to indicate whether this failure is a conscious suppression, or is an unconscious repression. Whether the organic patient sees but won't report, or actually fails to see the aftereffect is still an open question.

Summary

The Archimedes Spiral Aftereffect test was administered to 30 brain-damaged and 30 schizophrenic mental hospital patients who were comparable in terms of age and intelligence. Subgroups of each type of patient were tested under three different instructional conditions: reassuring, neutral, and anxiety-producing.

The two diagnostic groups differed significantly in their frequency of aftereffect report under the neutral and the anxiety-producing conditions. With the reassuring instructions, however, there was no significant difference between the two groups.

It was concluded that the common failure of brain-damaged patients to report the spiral aftereffect cannot be primarily a consequence of a neurophysiological incapacity for the perception of the phenomenon. It was suggested that the anxiety which characterizes most brain-damaged patients causes them to interpret the perception of the unusual aftereffect phenomenon as being indicative of mental disturbance. Consequently, they fail to report seeing it. Whether their failure to report it is suppression or repression has not been determined.

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THE RELATION OF PERSONALITY FACTORS TO GSR CONDITIONING OF ALCOHOLICS: AN EXPLORATORY STUDY[1]

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MANY WRITERS HAVE SUGGESTED that conditioning techniques could be employed to extinguish unacceptable behaviour patterns (Dollard & Miller, 1950; Mowrer, 1950). Conditioning has been attempted with alcoholics in an effort to develop a conditioned aversion to alcohol. While the majority of workers employing this technique use an emetic drug as the unconditioned stimulus, treatment is conducted in a number of ways. In a classical conditioning procedure, alcohol (the CS) is presented prior to emetine to evoke nausea (Skipetrov, 1953). Other therapists (Voegtlin & Lemere, 1940; Voegtlin & Lemere, 1950; Voegtlin, Lemere, & Broz, 1940) administer alcohol after emetine, so that the drinking of alcohol is coincident with the emetine-elicited nausea. This treatment could be considered as operant conditioning, if drinking alcohol is defined as the response which receives systematic negative reinforcement in the form of nausea.

Writers describing conditioned aversion treatment frequently note that the conditioned nausea response cannot be established in some alcoholics, even though they have a normal nausea reaction to the emetic drug (Voegtlin, 1947). Their observations suggest individual differences in conditioning the autonomic nausea response, but therapists have not found any adequate naturalistic criteria on which to select more suitable patients prior to actual conditioning trials. If a means of identifying the more conditionable alcoholics could be obtained, such information might have considerable practical application in the selection of patients who would profit most from conditioned aversion treatment. Since the nausea response elicited in this therapy may be considered to have some autonomic response components, a laboratory conditioning study of the autonomic galvanic skin reflex (GSR) may be deemed a suitable basis on which to begin an exploration of individual differences in conditionability among alcoholics.

There is some evidence to suggest that an individual's general ability to acquire conditioned responses is related to his position on a scale of introversion-extraversion, as this concept is defined in Eysenck's theory of personality (Eysenck, 1957). Franks (1956, 1957) investigated the rela-

[1]Paper presented at the Eastern Psychological Association Convention, New York, April, 1960.

tion between introversion-extraversion and ease of eyeblink conditioning in both normal and neurotic subjects. The conditioned response was found to be more quickly elicited and more slowly extinguished in introversive than in extraversive subjects. Also, conditioning was found to be unrelated to neuroticism, as defined by test scores on the Maudsley Personality Inventory (Eysenck, 1956). These findings are in line with Eysenck's theory which postulates that conditionability is dependent upon the introversion-extraversion variable, and is unrelated to the neuroticism factor (Eysenck, 1957). This assumption permits the prediction that conditionability of other responses in addition to eyeblink will relate solely to introversion-extraversion.

In order to test Eysenck's theory and to explore the possible relations of extraversion and neuroticism to GSR conditionability in alcoholics, the following predictions were made:

(1) A conditioned GSR will be elicited in fewer trials and will be more resistant to extinction in introversive than in extraversive alcoholics.

(2) No significant relations will be obtained between measures of conditioning and neuroticism in alcoholic subjects.

Method

Subjects

The study employed 22 male in-patients of the Alcoholism Research Foundation Clinic for alcoholism treatment. This hospital receives referrals from a variety of sources, and admission is not restricted on any economic basis. The sample contained alcoholics, admitted to the clinic during the time the study was being conducted, who were able to read and write sufficiently to complete a paper and pencil questionnaire. No subject was tested while under sedation.

Procedure

Conditioning took place in a semi-soundproof room. S was instructed that the test was one of relaxation or repose, and his task was to spell syllables as they were presented in a memory drum.

The conditioned stimulus was a nonsense syllable, "LAJ," which appeared 16 times, randomly placed among 35 other syllables of low association value (Glaze, 1928). A different one was presented every six seconds. The unconditioned stimulus was an unpleasantly loud ringing door bell buzzer which reliably elicited the unconditioned response of abrupt change in skin conductance. The first presentation of the CS was followed, in .5 second, by the US. A 50 per cent reinforcement schedule was employed, so that alternate presentations of the CS were reinforced. Skin resistance was measured by a Hunter Model 300 GSR amplifier, using hand electrodes and an Esterline Angus pen recorder which traced the GSR continuously.

The criterion of conditioning was similar to criteria employed in other GSR conditioning studies (Welch & Kubis, 1947a; Welch & Kubis, 1947b). In this instance, it was three consecutive GSR reactions to the CS when unaccompanied by the US. A GSR reaction was defined as the change in skin resistance accompanying the CS which was greater than those changes accompanying intervening buffer syllables. The

number of reinforcements necessary before this criterion was achieved constituted the measure of trials to acquire the CR. A larger score thus indicates slower or poorer conditioning.

A preliminary exploration of this conditioning technique showed that acquisition trials could not satisfactorily be continued much longer than 17 minutes, as Ss appeared to become restless. Frequently they made shifts in posture, sighed, or made comments to the experimenter. This activity also caused changes in skin resistance, and the regular chart record of conditioning could not reliably be obtained. For this reason, a maximum limit of 15 minutes was placed on acquisition trials. This permitted 24 presentations of the CS accompanied by US, and 24 presentations of the unreinforced CS.

Extinction commenced immediately after S displayed the conditioning pattern. The US was no longer presented, and S was permitted to spell the next 10 LAJ syllables presented by the memory drum. His GSR responses were recorded, and the number of reactions to the CS which were larger than his responses to any intervening buffer syllables was counted. These reactions were considered as the number of CRs during extinction. A larger score was taken to indicate greater resistance to extinction.

The Maudsley Personality Inventory which contains an extraversion and a neuroticism scale was administered to each S who underwent conditioning. Samples of British, American, and Canadian university students have been tested with this inventory (Bendig, 1958; Star, 1957; Vogel, 1958) and mean extraversion (E) scores from these groups have been found not to differ significantly from the mean E scores from normals reported in Eysenck's (1956) original research on this inventory. E scores from samples of male patients of the Alcoholism Research Foundation Clinic also have previously been found (Vogel, 1960) not to differ from Eysenck's (1956) mean E score of 24.6 for normal males. Since this score has frequently been employed to dichotomize a sample into "introversive" and "extraversive" groups, a similar procedure was followed in this research. The introversive category contained alcoholics with E scores under 25. The extraversive group was composed of Ss with scores of 25 and over. The number in each group was 12 and 10 respectively. In this sample, one S in the introversive category, and two in the extraversive category did not display the conditioning criterion within the maximum number of acquisition trials. Conditioning scores could not be obtained for these Ss, so the introversive group contained a total of 11 cases while the extraversive group contained 8.

Results

Table I summarizes a t test of the difference between group means. With 17 degrees of freedom the obtained t value of 3.59 is significant be-

TABLE I

Trials to Condition in the Introvert and the Extravert Group of Alcoholics

Group	n	Mean	S.D.	t
Introvert	11	5.18	1.75	3.59*
Extravert	8	12.25	5.85	

*With 17 df, $p < .005$.

TABLE II

CONDITIONED RESPONSES DURING EXTINCTION TRIALS IN THE INTROVERT AND THE EXTRAVERT GROUP OF ALCOHOLICS

Group	n	Mean	S.D.	t
Introvert	11	6.18	2.12	3.57*
Extravert	8	2.25	2.39	

*With 17 df, $p < .005$.

TABLE III

REGRESSION ANALYSES OF TRIALS TO CONDITION (Y) ON PERSONALITY SCORES (X)

(a) Extraversion scores (X)

Sum of squares X	Sum of squares XY	Sum of squares Y	Regression b	df	SD from regression $S_{y.x}$	SD of regression coefficient S_b	t
1389.69	489.79	538.53	.352	17	4.64	.124	2.84**

(b) Neuroticism scores (X)

Sum of squares X	Sum of squares XY	Sum of squares Y	Regression b	df	SD from regression $S_{y.x}$	SD of regression coefficient S_b	t
2884.11	−604.95	538.53	−.209	17	4.92	.092	2.27*

*With 17 df, $p < .05$. **With 17 df, $p < .025$.

TABLE IV

REGRESSION ANALYSES OF EXTINCTION SCORES (Y) ON PERSONALITY SCORES (X)

(a) Extraversion scores (X)

Sum of squares X	Sum of squares XY	Sum of squares Y	Regression $b_{y.x}$	df	SD from regression $S_{y.x}$	SD of regression coefficient S_b	t
1389.69	−307.37	166.74	−.221	17	2.41	.065	3.40**

(b) Neuroticism scores (X)

Sum of squares X	Sum of squares XY	Sum of squares Y	Regression $b_{y.x}$	df	SD from regression $S_{y.x}$	SD of regression coefficient S_b	t
2884.11	338.84	166.74	.117	17	2.73	.050	2.34*

*With 17 df, $p < .05$. **With 17 df, $p < .01$.

yond the .005 level. A test of the difference in group mean CRs in 10 extinction trials is presented in Table II. A *t* value significant beyond the .005 level is obtained.

As might be expected from the *t* analyses summarized above, a positive linear regression significant at the .025 level is obtained between acquisition trials and extraversion scores. This analysis is summarized in Table III. The number of acquisition trials increases as a function of increasing extraversion. A negative linear regression (Table IV) significant beyond the .01 level indicates that the number of CRs during extinction decreases as a function of increasing extraversion. Tables III and IV also reveal significant regressions of conditioning measures on neuroticism scores. Although these regression values are significant only at the .05 level, they permit rejection of the null hypothesis of no relation between GSR conditioning and neuroticism in alcoholic subjects.

Discussion

The significant regression of conditioning measures on extraversion scores agrees with the experimental hypotheses. Evidence of a relation between neuroticism and conditioning, however, is not congruent with Eysenck's theory and contradicts other work (Franks, 1956; Franks, 1957) which found no correlation between neuroticism and eyeblink conditioning in non-alcoholic normals and neurotics. Since this study only examined GSR conditioning in alcoholics, further research employing control groups of non-alcoholic normals and neurotics would be required to examine the extent to which the findings of this study may be generalized.

In the group of three alcoholics who did not condition within 24 trials, the introversive subject was subsequently found to have a marked hearing defect. No medical abnormalities were found to account for the inadequate conditioning of the two extraversive subjects. While the majority of non-conditioning subjects were thus found to be extraversive, and this result might be predicted from the hypothesis that extraversive subjects more slowly develop a CR, no conclusions may be drawn from such a small number of cases.

Summary

This study found introversive alcoholics acquired the conditioned GSR more quickly and extinguished this response more slowly than did extraversive Ss. In view of the theory which relates introversion-extraversion to general conditionability, this personality factor also may relate to the ease of conditioning other responses. To the extent that the conditioned GSR is comparable to the conditioned nausea response which is established in the aversion treatment of alcoholism, this introversive-extra-

versive personality factor may offer one means of distinguishing those alcoholics who would acquire the conditioned nausea to alcohol more quickly, and extinguish this response more slowly.

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BOOK REVIEWS

Plans and the Structure of Behavior. By G. A. MILLER, E. GALANTER, AND K. H. PRIBRAM. New York: Holt, 1960. Pp. xii, 226. $5.00.

ANYONE WHO HAS KEPT IN TOUCH with the speculation and work on mechanical simulation of thought will probably find himself skipping some sections of this book, but others who are considering whether to jump on the bandwagon should find it a useful introduction to the subject. The work follows a familiar pattern: in the first section the undeniable inadequacies of previous psychological theories are exposed, and a better idea is evolved; then the idea is applied to an assortment of psychological problems. The "idea" in this case, as might be inferred from the title, is called a Plan, and a Plan might be summed up as the premature fruit of an affair between the Aufgabe and a General Computer Program.

Plans can only be executed successfully under the joint control of the environment and some stored or inherited information about how the environment is organized; this is where the Image and the TOTE unit enter the scheme. The Image is defined as the sum total of the animal's previous experience; Tolman's cognitive map in fact. Possibly because so much of psychology up to the present has been concerned with the Image in one guise or another it gets little attention in this book.

The TOTE unit is introduced ambitiously in the second chapter to replace the reflex arc as the element of psychological analysis. The initials stand for Test-Operate-Test-Exit; they describe a feedback device by which the input and Image interact to determine behaviour. During the Test phase the input is compared with the Image; if there is an incongruity the Operate phase is established to reduce it. The new input is tested again, and the process continues until the Test indicates congruity and the control then passes to another TOTE unit via the Exit phase. Plans are hierarchical assemblages of TOTE units, the simplest Plan of all being a single TOTE. The authors point to the proprioceptive control of muscle movement at the reflex level as analogous to the operation of the TOTE, but make little further effort to indicate what mechanisms might be involved in the functions attributed to the units. Of course the authors are entitled to decide for themselves at what level of reduction they will stop their analysis, but in my opinion the whole point of computer analogies is that they can facilitate a closely argued molecular analysis; it is disappointing to find one used as yet another dummy around which descriptions of complex behaviour may be draped. It is

true that there is a chapter on Neurophysiological Speculations at the end of the book, but although it contains a good review of recent work, what speculation there is might better be described as Neuroanatomical. The behaviour changes resulting from damage to a particular area of the brain are described, and then "explained" in terms of what might have happened to the patient's TOTE units or Plans. But there is no mention of how the nervous system might actually perform the functions of storing, switching, comparing, and so on, that are required by the TOTE.

The intervening chapters are a series of essays, sometimes rather perfunctory, frequently provocative, but rarely as penetrating as one might have hoped, on such topics as problem-solving and "thinking" machines, intention and motivation, instinct (built-in Plans), motor learning (acquiring Plans), hypnosis (relinquishing Plans), speaking (Plans for constructing sentences), etc.

As a comprehensive review of a fascinating new influence on behaviour theory this book can be thoroughly recommended, but if the reader expects the triumvirate of authors to provide any substantial contribution towards a deterministic model let him take warning from the following typical sentence. "When we have decided to execute some particular Plan, it is probably put into some special state or place where it can be remembered while it is being executed."

PETER M. MILNER

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Adolescent Aggression. By ALBERT BANDURA AND RICHARD H. WALTERS. New York: Ronald Press, 1959. $7.50.

THIS BOOK DESCRIBES a study designed to seek the determinants of aggressive antisocial behaviour in child-rearing practices and intra-family relationships. Twenty-six adolescent boys whose conduct had either incurred incarceration in an institution, probation, or referral to a school guidance centre were compared with an equal number of boys described by their school counsellors as neither markedly withdrawn nor aggressive. Both groups were matched for age, intelligence and father's occupation. A standard series of questions was presented to the parents and boys. The family members were interviewed separately and simultaneously by three different interviewers and the entire proceedings recorded on audiographs. Data were rated on sixty-one 5-point scales directly from the interview recordings. In addition a projective-type test was used to assess the boys' reactions to socially-deviant behaviour. On the basis of previous

research, notably that of Sears *et al*, a number of hypotheses were formulated at the outset and tested as to their validity.

The results confirm the importance of affectional deprivation and rejection in the formation of aggressive tendencies. Significant determinants of such proclivities included parental disharmony, inconsistencies in the parents' handling of the child, and punitive discipline. Physical punishment, nagging, and ridicule were the means employed by parents in the aggressive group to control behaviour, while appeal to reason and withholding privileges were the practice of control parents. Significant differences were found in the sexual behaviour of the two groups of boys: 50 per cent of aggressive boys reported having had heterosexual intercourse—no experience of this kind was admitted by members of the control group. The authors conclude that defective conscience, that is behaviour more constrained by fear than by anticipation of guilt, is a striking feature of the antisocial personality. Inability to accept authority in any form has been a consistently marked feature of character disorders; an inability associated with a bad or inadequate relationship with the father (Stafford-Clark *et al.*). The present study indicates the probable nature of this relationship. Fathers in the aggressive group were found to have spent less time with their sons in early childhood, to have been generally punitive in their attitude, and to have encouraged aggression outside the home.

The antecedents of aggressive behaviour were sought in the environment and the investigators tend to discount the possible role played by constitution. For instance, the fairly high incidence of abnormal electroencephalograms found particularly among aggressive delinquents and criminals (Hill & Parr; Hodges & Grey Walter) probably results, the authors suggest, from the greater likelihood of this type of person incurring head injuries from repeated fighting, car accidents, and forcible arrests. Apparently overlooked is the fact that the majority of abnormal EEGs found in this group show an excess of theta activity (4–7 cycles/sec.) mainly in the central areas—a pattern said to occur normally in young children.

It is difficult to share the view of the author of the Foreword (Sears) that Bandura and Walters have set a new standard, at least methodologically, for the field of child development. Several important variables were uncontrolled, for example, the presence or absence of father during World War II—a period during which the majority of the boys must have had their early childhood. Religious influences and church affiliations were not considered in relation to the development of conscience, and it is doubtful whether father's occupation was a valid criterion of social status as marked cultural differences are discernible between the two

groups in the language, vocabulary and grammar manifested during the interviews. Furthermore, the probable transient nature of the opinions, attitudes, and criticisms expressed by parents and boys, in either group, on the findings as a whole, was not visualized. When a child in a family has been found delinquent the parents and child concerned tend to have a distorted view of each other's behaviour and personality. Faults, weaknesses, and foibles are exaggerated and redeeming features ignored. Social implications of the offence and any undue attention directed towards the family is usually accompanied by feelings of embarrassment, shame, and guilt on the part of the parents and child involved. Under more favourable circumstances the same people will tend to view each other through different coloured spectacles. On the other hand, participants in the control group would be more kindly predisposed towards each other as a result of having been informed they had been selected to take part in the investigation because of the good adjustment of a member of the family in school.

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Trends in Content Analysis. Edited by Ithiel de Sola Pool. Urbana: University of Illinois Press, 1959. Pp. 244. $7.50

The first trend in contemporary content analysis which struck me from this work was the multi-disciplinary nature of the search for reliable techniques. It is heartening to observe, in the chapter by G. A. Garraty, a historian who is not only patient enough to comprehend the potentials of psychological, linguistic, and anthropological approaches to content analysis but who is also capable of testing them out on his own biographical materials and ultimately making constructive criticisms and developments of his own. In another chapter, G. F. Mahl, a psychologist, presents a fascinating new method for inferring anxiety from speech disturbances and although his technique is demonstrated with psychotherapeutic material (where, incidentally, disturbances are displayed both by patient and therapist) the general usefulness of the method is clearly recognized by those working with biographical and propaganda materials or with formal speeches like those of W. J. Cameron for the Ford Hour on radio. C. E. Osgood, a psychologist, presents an analysis technique which stems from his work on meaning and attitudes and applies it to Cameron's speeches, psychotherapeutic interviews and Goebbels' diary with what appears to be a good deal of success. The wide applicability of Osgood's approach is appreciated by most of the

other contributors to this volume, especially by I. de Sola Pool, a political scientist. But it is not some generalized method that the eight contributors to this book are searching for. Rather they seem to be seriously looking over each other's contributions and evaluating them in terms of reliability, power, and potential usefulness in any academic domain.

The second trend which I perceived was a general agreement that content analysis contributes greatly to the task of making inferences from behaviour about antecedent states and that the process of drawing inferences should concern content analysts as much as the development of techniques. It is around this theme that the most exciting part of the volume turns: a debate between Osgood who uses a "representational" approach to make his inferences and Mahl who argues extremely well for an "instrumental" approach. This difference in orientations reflects the differences between Osgood and Skinner in their theories of language and meaning. (Mahl notes his own similarities to Skinner.) One might predict that the instrumental approach, comparatively, would demand that inferences stay close to observables, that nicely shaped envelope curves speak for themselves. But here is what seems to happen: a person says, "Man, is it hot!" and the representationalist takes it that this statement represents a state of personal heat. The instrumentalist goes much further, arguing that such a statement is most often emitted with some instrumental purpose in mind, for example, to prompt the audience to produce a beer or turn on the air conditioner. Mahl argues convincingly for paying attention to the context of verbal responses before inferring, but he does not give many ground rules for doing so. Osgood offers some substantial ground rules in this instance since he is equally aware of the importance of context.

Actually, the third major theme is the concern of nearly all participants with the problem of contextual verbalizations. The time has apparently passed when content analysts count verbal occurrences one at a time. Now the procedure is to deal with internal consistencies within passages where two or more verbalizations are recorded and analysed. Osgood presents a powerful method for contingency analysis which permits one to determine when two items occur at an above-chance level (for example, when Goebbels writes about "France" he links this item with comments about the "difficulties of obtaining food at home") or a below-chance level (for example, when a patient's talk about his "mother" is dissociated from his discussions about "homosexuality" or "masturbation"). This attention to behavioural contingencies is a psychology-wide one as seen in Hebb's and Bindra's work with animals where the coding of acts and their ordering becomes the basis for making inferences. The same trend is seen in Bales' interaction process analysis in small group work. It is

particularly encouraging to envisage what this procedure holds in store for the more complex cognitive processes of man.

This volume, which summarizes a conference on content analysis arranged by S.S.R.C.'s Committee on Linguistics and Psychology, is an excellent source-book for anyone in the behaviourial sciences. It goes far beyond demonstrating new and powerful techniques because it focuses on the major issues involved in the interpretation of empirical facts. The summary chapter by Ithiel de Sola Pool is remarkably comprehensive and instructive.

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Illusions and Delusions of the Supernatural and the Occult. By D. H. RAWCLIFFE. New York: Dover Publications, 1959. Pp. 551. $2.00 (Paperbound).

MR. RAWCLIFFE IS A British free lance journalist. In this book, first published in 1952 under the title *The Psychology of the Occult,* he goes to war against the ignorance, superstition, irrationality, and gullibility of many people who ought to know better. His battlefield is the wide domain of allegedly supernatural phenomena, ranging from crystal gazing and faith healing through mediumistic trance, the stigmata of the crucification, lycanthropy, oriental thaumaturgy, fire walking, and water divining, to such "modern" forms of psychical research as telepathy, clairvoyance, and precognition.

The author describes in some detail different kinds of better known occult, spiritualistic, and psychic practices and phenomena, and then proceeds to demonstrate that most of these, if not all, can be understood in terms of "psychological automatism, suggestion, hypnosis, hallucination, neurosis, hysteria, functional malady, sensory hyperacuity, delusion, fraud, prestidigitation, and limitless credulity." The exact combination of these factors, if relevant, may be different in different cases, but the list itself can be regarded as reasonably complete. Thus the author's main thesis is that "supernatural" explanations of the so-called "supernatural" phenomena are not necessary.

Throughout most of his work the author plays the role of an impartial, objective examiner of evidence for and against "supernatural" phenomena and his verdict against occultism is well documented. Sometimes, however, he slips. Although he holds up a stern finger to men like Rhine and Soal and chides them for not playing the game of science according to the accepted rules, he himself is occasionally carried away with his

zeal and resorts to questionable logic and reasoning. He plays somewhat fast and loose with concepts such as subconscious mind and mental dissociation in "explaining" various occult phenomena and sometimes also tends to jump to conclusions with overly short latencies. For instance, he claims that "it is undoubtedly a fact that unconscious articulation plays a very large role in the communication of cues during ESP tests" when his evidence only shows that under certain circumstances it is *possible* to communicate in this fashion.

On the whole, however, the author has done a creditable job in illuminating the vast and dark field of the occult and in so doing has provided his reader with a bill that is both entertaining and edifying. The author knows, of course, that no amount of rational argument or empirical demonstration can prove the non-existence of supernatural powers of the human mind, but he seems to hope that by presenting possible "rational" explanations for water divining, table-turning, ESP, and many other similar phenomena he can diminish the necessity for "supernatural" principles. Your reviewer does not quite share this optimism. It was recently reported that some Westinghouse Electric Corporation scientists are convinced that brain-to-brain telepathy is real and that they are studying the possibility of making use of this fact for long distance communication. It is a bit too much to expect that the board of directors of the company, after reading Mr. Rawcliffe's scholarly book, will stop wasting their money in chasing the mirage. After all, it is a well known psychological law that fairy tales are intrinsically more fascinating than the logic of scientific method.

Endel Tulving

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Essentials of Psychological Testing. By Lee J. Cronbach. Second edition. New York: Harper & Brothers, 1960. Pp. xix, 650. $7.00.

This is the second edition of the book which was first published in 1949. It has been completely revised, and brought up to date.

It is impossible to discuss a textbook of this sort intelligently without taking into account the audience for whom it was written. Cronbach in the preface, states that the book is intended for "undergraduates, and beginning graduate students in psychology and counseling." In the opinion of this reviewer, this is a good text for an introductory undergraduate course in psychological testing, although even for this purpose some teachers might find it unnecessarily simplified. It is far too elementary for a postgraduate course.

As a textbook on psychological testing, it has two very considerable advantages. First of all, no statistical or mathematical demands are made on the reader at all. However this advantage has not been obtained at the expense of the discussion of the fundamental psychometric problems of reliability, validity, and standardization. Also, each statistical procedure is explained to the reader very competently indeed with the aid of easily understandable diagrams, and the implications of these statistics are made quite clear.

If this book errs at all, it is in underestimating the capacity of the undergraduate student approaching psychological tests for the first time, even without prior statistical knowledge. The 1937 revision of the Stanford-Binet test was in many ways a landmark in the history of psychometrics, because of the complexities involved in standardizing an age scale as contrasted with a "point" scale. Indeed Quinn McNemar wrote a book (*The Revision of the Stanford-Binet Scale*, New York: Houghton Mifflin, 1942) describing the statistical ordeals involved, and the revision of the Binet was the last major age scale attempted. Nevertheless none of the technical difficulties involved in this Binet revision are discussed by Cronbach, and age scales in general are made to sound deceptively simple to construct and standardize.

Occasionally, in an attempt to simplify, the author is guilty of misleading the reader seriously. For example, on page 223, when discussing speeded *versus* unspeeded tests of intelligence he writes: "The trend in recent American tests is to provide ample time for nearly everyone to finish. This point of view is not universally accepted. Eysenck (1953) and Furneaux in England argue that the speed with which the mind produces hypotheses is the essence of good problem solving, and that a speeded test is therefore the best measure of mental ability." This is to misrepresent Furneaux's position completely, since Furneaux has argued strongly that measuring any single intellectual characteristic (speed, error, or persistence) gives a completely inadequate description of intellectual capacity, and that what is needed are various tests, each producing relatively pure measures of each of these aspects of cognitive function. Indeed what Furneaux means by a test of intellectual speed is not simply a speeded test, since this is an impure measure.

In spite of these minor defects, this text is one of the best introductory books on this subject which I have so far read.

R. W. Payne

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